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NEW
Third Edition

Ulrich Schueller
Hans-Georg Veddeler

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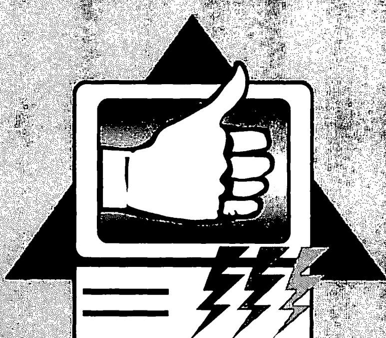
Section I

General Information



CHAPTER 1 Introduction

Before discussing the various elements that make up a PC system, let's define the terms "upgrading" and "maintaining".

Upgrading a computer means increasing its performance level. Usually this is done by adding hardware and/or replacing existing hardware with more advanced components. For example, you could add memory chips, which increases your PC's storage capacity.

You could also install a more powerful processor by replacing your computer's motherboard. This would enable your PC to perform tasks that the old processor couldn't handle, such as the following:

- Faster screen redraws which is usually important when you use graphic applications.
- Faster data calculation and processing.
- Faster loading and executing of applications, especially graphic applications.
- Running Windows and Windows-based software faster.

So, by upgrading, your entire system becomes more powerful and efficient.

However, upgrading also involves using a compatible set of components, expanding your PC's hardware with specific applications, and understanding how these components work.

Increasing the efficiency of the main application, instead of simply adding loads of memory and speed, is the main reason for upgrading a PC.

Obviously a computer used as a CAD workstation and a computer used for general office work have different hardware

requirements. However, even two CAD workstations can be configured differently. For example, one may use a different operating system, such as OS/2, instead of DOS.

Your experience level is another factor you should consider before upgrading a PC. The best hardware and software combination won't increase your efficiency unless you know how to operate the application properly. Often it's useful to improve your own computing skills before investing in new hardware.

Maintaining your computer is a simple concept. It involves understanding the components of a computer system and how they operate so you can keep them in good working condition. Often, maintaining your computer also requires some troubleshooting when problems occur.

Again, understanding how the components work and relate to each other helps you isolate problems and find solutions.

The chapters in this section provide general information about PC systems. With this information, you'll be able to determine the best upgrading strategy for your PC.

When to upgrade

CPU upgrade package

If your system and software are running slowly but satisfactorily, then you should consider buying a CPU upgrade package. This is especially true if you're using graphic or CAD programs (including graphic intense games), desktop publishing, multimedia or data-oriented software.

Buying a new system

If you have an 8086 or 8088 based PC, it's much better to upgrade your entire system. Even if you have an 80286 based PC, upgrading the processor to a 386 or 486 usually is recommended because the rest of the system is designed to work with the slower 286 processor.

Industry standards

If your system follows industry standards, you should have no problem upgrading. If not, you'll need to determine your upgrading options by checking with both the seller of the upgrade or your

original computer manufacturer to determine what on your system can be upgraded. You must find out if a certain upgrade will work with your system.

The BIOS on many older PCs may also need to be upgraded.

Multimedia Upgrade Kits

The most economical way to upgrade your system to multimedia may be to purchase a multimedia upgrade kit. Since the upgrade kits may vary in contents, features and price make certain to know what you need before shopping. At the very least purchase a kit which has a CD-ROM drive and sound card. Other upgrade kits may include software, speakers, microphone and other equipment you may not need.

See Chapter 9 for more information on multimedia and upgrading your system.

Can I upgrade my 486?

Even a 486 processor can be upgraded by using the OverDrive chip technology by Intel. You'll probably have two choices:

- Plug the OverDrive into a special slot in your system designed for it.

- Remove the existing processor and replace it with the OverDrive chip.

Intel has several OverDrive upgrades available. For example, upgrading to a 486DX2 processor from a 486SX or 486DX processor. See Chapter 2 for more information on the OverDrive and the 486DX processor.

CHAPTER

2 Functions Of A PC System

In this chapter we'll discuss the components of the PC system. Each component will be explained individually and analyzed according to how it relates to a performance upgrade of the entire system. We'll start by explaining the basic structure of a personal computer.

A personal computer is simply a machine that processes information (data). Like other machines, a computer does what it's told to do. We tend to forget this fact when we encounter a problem with our computers. We may automatically blame the computer for the error although many times we are to blame.

For example, when a cup of coffee is too strong, we assume that we used too much coffee or not enough water. In other words, we don't blame the coffee machine for the mistake. However, when a PC produces an undesired result, we usually blame the program or the computer system itself although we probably caused the error.

IPO principle

The coffee machine example above follows the IPO (Input-Process-Output) principle. As long as the input is processed according to the same rules each time, the output depends on the input.

This process is more complicated with an entire computer system, which consists of hardware, software, and peripheral devices. This is mainly because the PC consists of several smaller systems, which operate according to the IPO principle.

The output of one system (for example, the output signal of the video card) is the input of another (in this case, the monitor). This system's output (the characters on the screen) are, in turn, the input for the "human information processing system", in other words, yourself.

Then you process what you see on the screen and produce additional output (perhaps by entering a command line on your keyboard). This then provides new input for your PC and the active application. All the systems involved in this process operate according to the IPO principle.

Every system that processes information can be divided into at least three stages: Input or receiving information, processing information, and output the resulting data.

If, in addition to these functions, the system is also capable of retaining information, a fourth element, called storing data, is added.

The individual components of your PC, as well as the devices connected to it or installed in it, belong to either the "Input and Output", "Processing", or "Storage" function group.

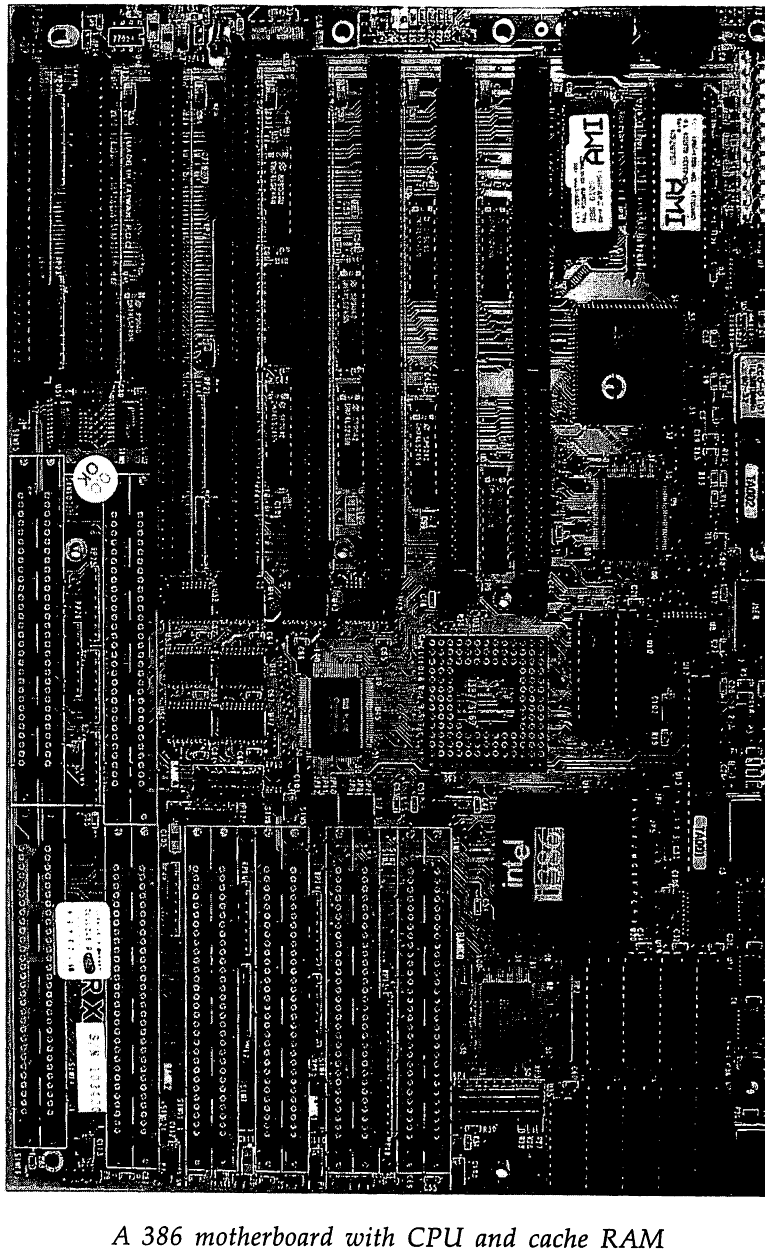
In this chapter we'll describe the individual elements of these function groups and discuss ways to increase your system's efficiency by improving how these components work together and with the application you want to run. In Part II we'll discuss these procedures in detail.

First we'll discuss the Processing group and then the Storage group. Since Input and Output mainly consist of external devices (actually interface cards that allow these devices to be addressed), we'll discuss them at the end of the chapter.

2.1 Processing

The components that belong to the Processing group are located on the PC's motherboard. The term "motherboard" is used because all other component groups and peripheral devices are controlled from this location.

The motherboard contains the bus, CPU and processor sockets, memory sockets, keyboard controller and supporting chips. Except for its input and output ports and the mass storage device, which are peripherals, the motherboard actually comprises a PC system itself. The motherboard acts as the central component of the PC system.



A 386 motherboard with CPU and cache RAM

The motherboard determines the performance class to which the overall system belongs. We'll discuss the performance classes in more detail later.

The actual processing of information always takes place on the motherboard.

Some components are interchangeable

If the PC system is located in a desktop case, the motherboard is attached to the bottom of the case. However, tower and mini-tower cases are becoming more popular. In these upright cases, the motherboard is attached vertically to one side of the case.

A motherboard's dimensions (i.e., its size, the location of its mounting holes, etc.) can vary depending on the manufacturer. Some motherboards are from brand name manufacturers and others are generic, or no-name, boards. Most generic motherboards have the same dimensions and, therefore, always fit into a generic case.

However, brand name manufacturers don't want their boards to be swapped with boards from other manufacturers or with generic boards. So usually only boards and cases from the same manufacturer will fit together.

This is one of the reasons why you should purchase PC clones. They allow you to swap components or add more powerful components. You'll find a listing of generic dimensions for boards in the available sizes in the Appendix.

Brand name components are less flexible

Several manufacturers, such as Zenith and Tandon, have rediscovered an old convention: Treating the main board as an expansion card. So, the bottom of the case contains only the bus and several expansion slots. Like other expansion cards, the motherboard is plugged into one of these slots.

The advantage of this setup is that you can easily replace the motherboard with a more powerful one. However, you must use the same brand motherboard as the replacement. This unfortunately means you must depend on the latest developments and prices of the manufacturer.

Repairing motherboards

Modern motherboards generally consist of a nonconducting material, which is insensitive to heat (e.g., Pertinax). You can imagine this type of construction as several layers of printed circuitry. A current flows through several fine conducting lines on

each of these layers. These lines are connected to the various chips and other components on the surface of the board. You can easily see these lines on the motherboard.

CAUTION

If one of these conducting lines is broken, either by physical damage or an electrical short, your entire motherboard may be unusable. Because of the complex multilayer construction of modern boards, these components are almost impossible to repair. So you should always handle the motherboard carefully.

Contains important components

As we mentioned, the motherboard contains all the components needed to actually process a task. The most important components, the processor and math coprocessor, form the PC's command headquarters. However, the system and main memory, as well as the data and address buses, are also extremely important components of the motherboard.

We'll discuss these and other components in more detail in the following sections. Remember that not all these components can be swapped for others, sometimes not even for more powerful ones.

The Processor (CPU)

The most important chip on any PC motherboard is the processor. Without it, the PC system wouldn't operate. This component is often referred to as the CPU, or central processing unit, which clearly identifies this component's role within the system.

The CPU manages every step in the processing of data. It acts as the conductor and supervisor of the system's hardware components. Also, it's linked, directly or indirectly, with every other component on the motherboard. Therefore, many component groups are addressed and activated directly by the CPU.

The processor is equipped with address buses, data buses, and control buses, which enable it to perform these tasks. These bus systems are configured differently, depending on the processor class of the PC, which we'll discuss later.

During the development of PCs, the architecture, or inner workings, of CPUs have evolved drastically. An ever-increasing number of transistors and hardwiring have been integrated in extremely small spaces to meet the rising performance demands placed on PC processors.

The most advanced PC processor available is the Intel 80486. This processor contains over 1.2 million transistors on a ceramic tile that's about three square inches and an eighth of an inch thick. The CPU, the math coprocessor, and 8K of cache RAM are located in this area.

Since so many components are located in a very small area, a special manufacturing technique is needed. This technique enables elements, which are only a mere micrometer (one millionth of a meter), to be constructed.

To see how small these structures are, consider that a single human hair is width enough to cover about 100 of these elements.

Which performance class an entire PC system belongs to is determined by the processor chip.

Clock speed

An important factor in determining the processor's performance is its clock frequency or speed. The CPU is driven by a quartz crystal, which is an external frequency source. The clock frequency, with which this quartz sets the beat for the processor, is measured in pulses per second, and is specified by the unit "megahertz" (MHz).

The rate at which a processor works is largely affected by its clock speed, the frequency at which it executes instructions. One megahertz (1 MHz) corresponds to 1 million pulses, or clock ticks, per second. So a 80386 CPU operating at a clock speed of 33 MHz, for example, can perform an operation 33 million times each second.

The external clock speed is the speed at which the processor accesses information outside itself, in external cache memory or system RAM. The internal clock speed is the speed at which the processor obtains information within its own confines—in its registers or in its internal cache memory.

A processor with a higher clock speed normally run proportionally faster than an otherwise identical system and processor with a lower clock speed. A 486DX with a clock speed of 50 MHz computes twice as fast as a 486DX with a clock speed of 25 MHz.

Clock-doubling processors

In 1992, Intel introduced its clock-doubled 486DX2 processor. The internal clock speed of the 486DX2 processor is twice its external clock speed. So, any calculation performed on data completely inside the processor chip runs twice as fast as a calculation that must get its data from external memory. Now all manufacturers of 486 processors offer clock-doubled models. IBM is the only manufacturer currently offering a clock-tripled processor.

Usually, a processor with the notation 33/66 is a processor operating at a 33 MHz external clock speed and a 66 MHz internal clock speed.

NOTE

Many advertisements may list a processor in a system as a "486 66 MHz" when the processor actually has an external speed of 33 MHz and an internal speed of 66 MHz.

Most clock-doubled processors compute about 80% faster than a non-doubled counterpart running at the same external clock speed. It is, however, slightly slower than a processor whose internal and external clocks match the higher speed of the clock-doubled processor. For example, a 33/66 processor computes faster than a processor with a 33 MHz internal and external clock speed but slower than a computer with full 66 MHz processor.

NOTE

A faster processor will not make every operation or system component faster. Hard disk access speed, printing speeds, and modem transfer rates do not change. However, a faster processor does accelerate graphics on most graphics cards which can be significant when you're in Windows.

Internal cache memory

Internal cache memory is a form of fast memory that retains a copy of frequently used data and instructions. Processors with a large cache memory can hold more information and therefore run faster than processors with smaller cache memory.

External cache memory

This cache memory is built onto the system board of your PC. It also increases the speed of frequently used data and instructions. External cache memory sizes range from 64K to 1 Meg. The greatest improvement in system performance is probably the first 64K of external cache memory. The benefits diminish when you add more external cache memory.

Power management

A processor with power management capabilities such as System Management Mode (SMM) can put itself in a sleep mode if it isn't used for a certain length of time. It therefore requires minimum power to operate, however it has enough to sense a keystroke or mouse movement. It then returns to full power. Most notebook computers have this feature to prolong battery life.

Power management features also now extend to shutting down unused hard disks, modems, printers or other peripherals.

NOTE

Processors with power management features normally require BIOS firmware or other software to work effectively.

Operating voltage

The strength of the electric current which the processor receives is its operating voltage. Processors are normally available with two operating voltages:

- 3.3-volt processors are used when power consumption is a major consideration such as notebook computers.
- 5-volt processors remain the standard for desktop computers.

Processor sockets

A grid of small holes on the motherboard is where the processor is inserted. This grid is called the processor socket.

Fortunately, new ZIF sockets have eliminated the force required on older processor sockets to insert or remove a processor. A ZIF (zero-insertion force) socket uses a simple lever which loosens or tightens its grip on the chip.

TIP

If you're upgrading your complete PC system, make certain the processor is mounted on a ZIF socket. This will make future upgrades much easier and possibly less expensive.

The other components on the motherboard have evolved along with the processor itself. These components have been adapted according to the changes made in processor technology.

Development of the processors

To understand the information presented in this chapter, first you must know how the processor has changed throughout the years. So we'll briefly discuss the history of personal computers and the evolution of microprocessors.

Intel 8086/8088 CPU

Intel is the leading manufacturer of microprocessors for IBM compatible computers. The 8086, 80286, 80386, and 80486 processors developed by Intel since 1978 represent four generations and performance classes in the history of microprocessors.

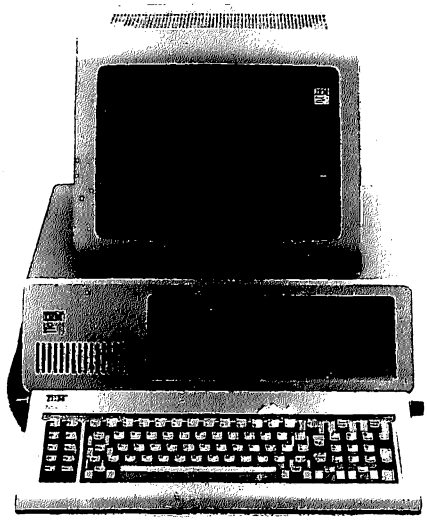
Intel introduced the 16-bit 8086 microprocessor in 1978. This was the first processor for which convenient development support, higher level programming languages, and more powerful operating systems were available. This established the basis for PC development. Since then all IBM compatible systems have been based on the 8086 CPU.

All descendants of the Intel 8086 must be capable of emulating this processor. Software that was designed for the 8086 also must

operate on the succeeding chips. The 8086 was a rectangular chip with 20 prongs.

These prongs were used to insert the chip into a socket on the motherboard. Usually the chip was placed next to the expansion slots and in front of the keyboard input connector.

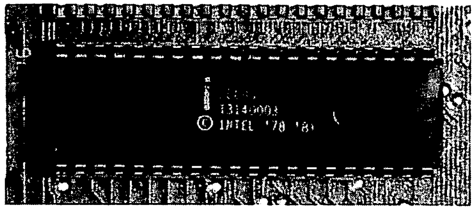
The 8086 was designed with a true 16-bit structure, which enabled it to work with a 16-bit data format both internally and externally. However, the high price of the necessary memory components prevented the 8086 from becoming very popular.



1981 IBM PC

IBM contracted Intel to design the successor to the 8086 chip, the 8088 CPU. The first personal computers were introduced in 1981. These computers, which had an amazing 16K of memory, a cassette tape drive, and a non-graphics green monochrome monitor, were based on the Intel 8088 processor.

Externally, the 8088 used only an 8-bit format for its data bus. Although this limitation cost about 25% of the processor's performance, it simplified the organization of the addressable memory.



The Intel 8088 processor

The 8086/8088 CPU was equipped with a 20-bit address bus, which allowed it to address 2^{20} memory locations. This is equal to 1 Meg or 1,048,576 bytes, which forms the physical memory limit of the 8086/8088 processor. The processor originally operated at an impressive clock frequency of 4.77 MHz.

The XT computers were upgraded versions of the IBM PCs, with hard drive capability. Later, various "Turbo XT" compatibles had 8 MHz, 10 MHz, and even 12 MHz clock speeds.

Compared to the power that's available today, it's difficult to image how a computer with an 8086/8088 processor could be useful. However, the software that was available at that time didn't require much power. Even a more recent word processor such as Microsoft Word 5.5 could operate properly on an 8088 CPU.

80286

In 1981 Intel introduced a more sophisticated processor, the 80286 CPU, which raised PC performance to a new level including the IBM AT and original PS/2 50 and 60 models. The 80286 processor used a 16-bit data bus internally as well as externally. This enabled it to outperform its predecessor, especially since more powerful applications were being developed for PCs. This processor's address bus had also been expanded to allow it to directly address 16 Meg of memory.

IBM marketed its first AT (Advanced Technology) models (AT-02 and AT-03) with clock frequencies of 6 and 8 MHz. Subsequent compatibles raised the clock speed to 12, 16 MHz and 20 MHz.

Another basic difference between the 80286 and its predecessor was the new CPU's condensed command set. This increased the number of instructions that could be executed per second not only through an increased clock frequency, but also through a more efficient command structure.

As a result, the MIPS (Million Instructions Per Second) value was tripled.

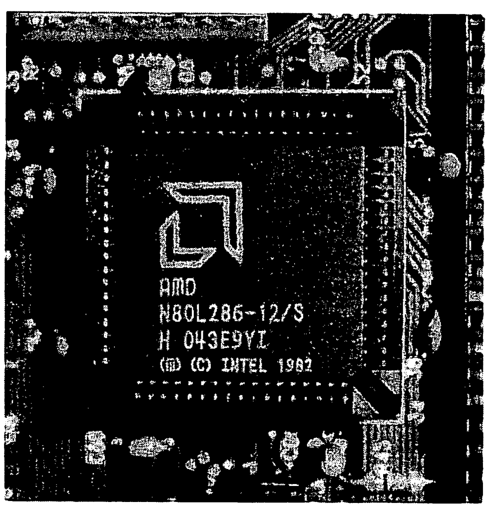
Protected mode

The crucial difference between the 8086/8088 and the 80286 CPUs was the addition of a new operating mode. In Real, or normal, mode, the 286 operates in the same way as its predecessor; the same 1 Meg memory limit applies.

However, its increased clock speed and more efficient command set allowed it to outperform the older CPU, even in Real mode.

The new operating mode, called "Protected mode", allows the 80286 processor to directly address and manage the full 16 Meg of memory. So it's possible to process several different applications simultaneously. This technique is called "multitasking."

The 80286 was Intel's first processor capable of multitasking that was extensively marketed for PCs. However, only a few applications, such as Lotus 1-2-3 or Microsoft Windows, could actually use this capability. The MS-/PC-DOS operating system on its own cannot operate in Protected mode because it can grant applications access to only 640K bytes of memory. However, other operating systems, such as UNIX or OS/2, are capable of Protected mode operation.



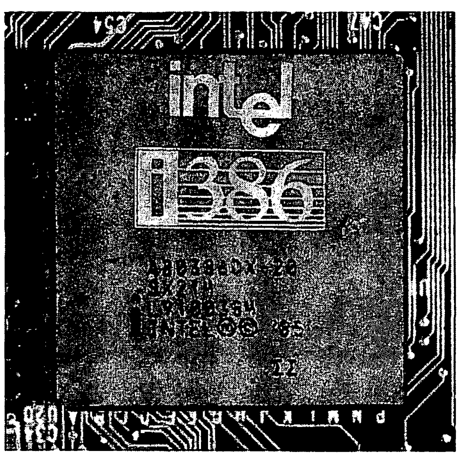
The Intel 80286 CPU

In PCs of the AT (Advanced Technology) class, the 286 processor is often found in the same form and the same location as in the 8086/8088 CPU. However, the 286 chip was never produced in one specific format. It can be a square wafer secured by metal retaining clips or a square chip inserted in a plastic socket. Its location on different motherboards also varies. Usually the only way to identify this chip is by the inscription found on its surface.

The 80386 processor

The next generation of PC processors brought about drastic changes in the PC world. With the 80386DX CPU, Intel introduced a processor chip that was far superior to the earlier processors for high speed operation and multitasking operations. The 386DX was the first 32-bit processor to be used on PC motherboards. Doubling the width of the data bus used in the 286, both internally and externally, created more possibilities for personal computers.

Graphics applications that previously ran slowly could now be executed more quickly. Also, graphical user interfaces (GUIs), which redraw the entire screen after each action, required much of the processor's power. But after the 80386DX CPU was introduced, using these interfaces on a PC became more practical.



The Intel 80386DX CPU

Since clock speeds were then raised from 16 to 33 and 40 MHz, and external cache RAM was installed to enhance the processor's performance, almost all modern PC systems could be classified as "graphics computers."

However, this distinction had already existed among Commodore Amiga and Atari ST computers, which use Motorola processors.

Since the 386's address bus was expanded to 32 bits, the chip is capable of directly addressing 4,294,967,296 (2^{32}) memory locations, or 4 gigabytes of RAM.

This even makes it possible to address 64 terabytes (2^{40}) virtually, which permits another operating mode, called the Virtual Real mode.

With this operating mode, multitasking is possible under MS-/PC-DOS because each application involved in the multitasking process receives a virtual CPU with 1 Meg of memory.

The applications also receive their own resident copy of the operating system. These separate virtual computers operate like several independent 8088 processors working in parallel in a single system.

However, to create this artificial PC world, another addition to the operating system was needed. This addition was soon introduced by Microsoft as Version 3.0 of the graphical user interface MS-Windows.

Like the 286 CPU, the 386 remains completely object-code compatible to its predecessors. This means that all operating systems and applications designed for 8086 or 80286 processors will also run on the 386 CPU, only much faster.

The 386 also understands the command sets used by the older chips and the execution times are much faster. At an identical clock speed, for example 16 MHz, the 386 can reach twice the MIPS (Million Instructions Per Second) value as the 80286 CPU.

The 386SX processor

A special feature of the 386 generation is that a scaled-down version of the processor, called the 386SX, is available. This

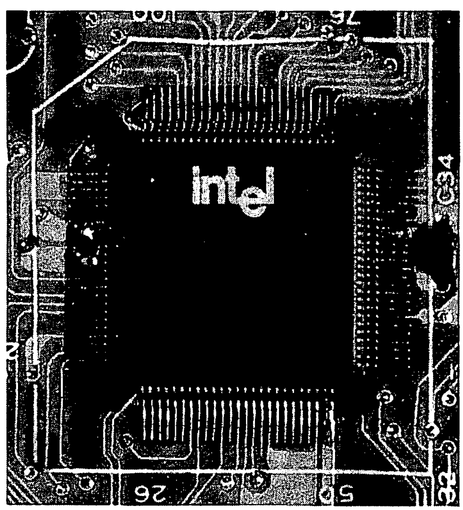
version, which has clock speeds of 16 to 25 MHz, uses a 32-bit structure only internally. In this way, it's identical to the 386.

However, externally the SX uses a data bus that's the same size as the bus found on the 286 CPU. Because of this, the multitasking capability cannot be fully used.

The 386SX basically consists of a 386 processor on a 286 motherboard. This is why the SX performs many tasks noticeably slower than its big brother, the "real" 386.

It must constantly switch between its own internal 32-bit structure and the external 16-bit operation.

You can easily identify the 386DX on the motherboard. It has a square shape, a distinctive inscription, and a blue-red tint. The 386DX CPU is usually located across from the expansion slots on the motherboard.



The Intel 386SX CPU

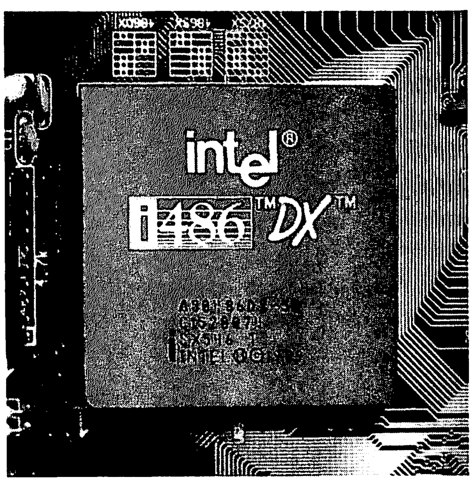
Since processors of the 386SX class are considerably smaller, it's difficult to locate them. Instead of being mounted in a socket like other Intel processors, they are soldered directly to the circuit board. So they cannot be removed or exchanged. If a 386SX CPU stops working, the entire motherboard must be replaced.

The 80486 processor

The next processor from Intel is the i486. This CPU, which is more than just a processor, is called an integrated chip. This chip consolidates four different function groups (the actual CPU, a math coprocessor, a cache controller, and two 4K caches) in one component. The i486 uses a full 32-bit structure, both internally and externally, and works at clock frequencies of 25, 33, 50 and60 MHz.

Main difference

The main difference between the i486 and its predecessors, particularly the 386 chip, is the i486's high level of integration. Even a 386 together with a coprocessor isn't comparable to the i486. While the 486 processor is integrated with its coprocessor, the 386 CPU must communicate with its coprocessor through bus connections. This detour slows down the communication between the processor and the coprocessor. The integrated construction of the i486 eliminates this detour completely.



The Intel i486DX CPU

The i486's integrated structure has a cache controller built into the chip, along with two 4K caches. You may be wondering why there is a storage element inside a processing component. Like the external cache located on the motherboard, this on-chip cache acts as a buffer between the processor and the main memory. Since the basic operation of the integrated cache is identical to the external "second level cache", refer to the description in Section 2.1. It explains the principle of RAM caching in detail.

The internal cache located in the i486 is set up as a "buffered write through" cache. This method reads data, which cannot be found in the cache, from main memory and passes this information to the CPU and the cache. Write operations to memory locations that are currently also stored in the cache are made to both the main memory locations and the cache.

Uses internal management algorithm

This ensures that the information in the cache is current. An internal management algorithm buffers these read and write operations until the external bus is available and the PC's main memory can be addressed. This frees up the processor and prevents waiting periods.

The cache contents that are used the least within a certain time period are identified by a special control algorithm and are overwritten the next time the cache is refreshed.

Because of the internal cache controller, the CPU, with its high operating frequency, rarely has to wait for the PC's rather slow RAM. The cache acts as a type of intelligent buffer, a characteristic that can be ascribed to the cache controller. Since this technique is able to prevent almost all waiting periods, the i486 can execute almost all operations within a single clock cycle. This capability alone makes the i486 clearly superior to the 386.

Complete command set

The i486 has a complete command set, which includes all the command sets used by its predecessors. This results in a complex processor architecture. Like its predecessors, the i486 is a CISC (Complex Instruction Set Computer) and is downwardly compatible.

Downward compatibility means that the i486 will run applications originally written for the earlier processors, including the original 8086. CISC processors are very flexible because of their comprehensive command sets. However, this capability also decreases their speed.

RISC processors

RISC (Reduced Instruction Set Computer) processors, however, achieve higher productivity levels by using a reduced command set, which is usually tailored to a specific application (such as CAD). However, this means that the processor's command set may not be able to execute other applications. So the speed is increased while the flexibility is decreased.

The i486 is a compromise between a maximum level of flexibility and a processing speed that's remarkably high for a personal computer system. The complexity of the CISC processor and the speed of the RISC processor are successfully combined in the i486.

Feature oriented processors

As you'd expect, things in the computer world have a habit of changing quickly. In rapid succession, Intel has introduced several new 486-class processors. These processors fall into two categories:

- Feature oriented processors
- Performance oriented processors

The new feature oriented processors are designed to be used in computer systems that use less electrical power. Not too long ago, these types of processors were the notebook, subnotebook, and handheld computers.

But now these computer systems include a new emerging generation of environmentally friendly desktop computers that consume less electrical power. The new performance oriented processors are designed to deliver more computing power to the user at far less cost.

We'll talk about these categories separately. First, we'll discuss the new feature oriented 486 processors.

SL processors

Designed for mobile computers

The SL processors were originally designed to be used in mobile computers - laptops, notebooks and subnotebooks. These processors operate at 3.3 volts instead of the 5 volts required by their predecessors. Since they use less power they extend the life of the batteries which run them.

System Management Mode

In addition, an SL processor has a special System Management Mode (SMM) which can control the functions of a computer. For example, SMM can dim the LCD screen, turn off a hard drive, or reduce the speed of the processor, which also extends the life of the batteries. The main function of SMM is power management.

The key to SMM is a new interrupt called the SMI (System Management Interrupt) and a new address space in which the SMM routines are executed. This separate address space is independent of the 486's main address space so it doesn't interfere with operating system routines or application programs.

When the computer system requires a power management service from the SMM program, it issues an SMI to the 486 processor. The processor begins running the SMM program in its own address space, performs the requested service, and then exits the SMM program using a new RSM (Resume) instruction.

The computer system is right back where it left off and isn't even aware the system may have been suspended for a few minutes, hours or days by the SMM.

Most of the latest 486 processors incorporate the SL power management features at no additional cost. Except for operating at 5 volts, the 486SX, 486DX and 486DX2 processors now contain the SL features. These new chips are known as the SL Enhanced 486 processors. In fact, some of the newer processors will even operate at 3.3 volts.

Require less energy

Using these new features, computer manufacturers will be able to build computers that use less energy. The same processor that is used in a mobile computer can also be used in a desktop computer. This makes it easier for manufacturers to standardize their computer systems and design "green" computers with an additional goal of helping to save the environment.

Performance oriented processors

If you've used a personal computer for at least a few years, then you've witnessed very dramatic jumps in performance and likewise very drastic drops in the price that you pay for that performance.

These tremendous price/performance gains have been spurred by Intel, which has been rapidly developing and introducing new microprocessors at a frenzied pace ever since the first IBM/PC was launched more than ten years ago.

Three relatively new, but related, Intel introductions have slightly changed the definition of the original 486 chip. These new technologies are derived from the 486 chip and are aimed at extending the life of 486 computers and ensuring a smooth transition for both users and computer builders to the next generation of post-486 computers.

The first two of these technologies are called the Clock Doubling and OverDrive processors. For marketing reasons, Intel has given them different names, but the technology is identical.

The third of these technologies is the Pentium processor which is the successor to the 486 processor.

Clock-doubling processors

The 486es are part of a family of processors. The different members of the 486 family are designated by a suffix and a clock speed.

Suffix	486 Family Member
DX	486 with math coprocessor
SX	486 without math coprocessor
SL	486 with math coprocessor operating at 3.3 volts

Clock speed
16 MHz, 20 MHz, 25 MHz, 33 MHz, 50 MHz

As you know, the performance of a computer depends mainly on how fast the processor can execute instructions. The rate at which a processor can execute those instructions is determined by the processor's clock speed.

Remember the processor communicates with the external components of the computer system - main memory, hard drives, modems, and printer ports for example - at this same clock speed. Each computer manufacturer such as IBM, Compaq, AST or Dell designs its computer systems so all these components can communicate reliably at that clock speed.

From it's name, you can probably guess how speed doubling technology works. A 486 processor with clock doubling technology executes at double the normal clock speed.

A clock doubling processor is designated by the suffix DX2 or SX2. A standard 486DX-25 processor or 486SX-25 processor operates at a clock speed of 25 MHz. This means that both internal and external operations are performed at 25 MHz.

The clock doubling version of these chips are the 486DX2-50 processor and the 486SX2-50 processor respectively. When either the 486DX2-50 or the 486SX2-50 is performing integer or floating point operations, it performs them at 50 MHz. When it has to access to main memory for data or instructions, it does so at the normal 25 MHz clock speed.

From the above description, you can see that the performance gain is double only for internal CPU operations, in which it accesses only components internal to the processor.

The speed of external operations, those where the processor has to access components external to the processor, isn't increased. Intel claims that the overall advantage of a DX2 or SX2 processor over a DX processor is that it's from 50% to 70% faster.

It may not be obvious, but speed doubling technology is a great invention. Because the DX2 or SX2 processor communicates with the rest of the computer system at the normal speed, a computer manufacturer does not have to redesign his computer system to achieve a higher level of performance.

By merely substituting a DX2 or SX2 processor in a system designed for a DX processor, the manufacturer can offer a new model with 50% to 70% increase in performance, for example.

What do you get when you combine speed doubling technology with the new SL Enhanced 486 processor technology? You get a new Intel 486DX2/40 processor. This chip runs internally at 40 MHz and externally at 20 MHz. Since it consumes only 3.3 watts of power and has a built-in SMM, it's perfect for notebook and subnotebook systems.

OverDrive processors

A companion to a clock doubling processor is the Intel OverDrive processor. Speed Doubling processors and OverDrive processors operate the same way. They are different only in how they are sold and packaged.

You can only buy a DX2 or SX2 clock doubling processor in a complete computer system. Intel does not sell either processor to end users. Instead, Intel sells them only to computer manufacturers, who build the computer system, who in turn sell them to end users.

An OverDrive processor however is user-installable. This means that you can go to a computer dealer, purchase the OverDrive processor, and install it into your 486 computer system yourself.

The package includes a chip puller and instructions for removing the old chip and installing the OverDrive. Intel also provides a fax-back service that you can use to obtain specific information about the model in which you intend to install the OverDrive processor. Consider the possibilities of immediately supercharging your computer system by popping one onto your motherboard.

For 486SX systems, you can plug the OverDrive processor into the 169-pin PGA socket. This is the same socket used for the original 487SX math coprocessor. When you upgrade an SX system with the OverDrive processor, you also get a built-in math coprocessor. So for 486 SX systems, you benefit from the Speed Doubling technology and faster execution of floating point operations.

For 486 DX systems, there are two variations of OverDrive processors. The first type is for computer systems that have a dedicated 169-pin PGA OverDrive socket on the motherboard. To upgrade these systems, simply install the OverDrive processor into the dedicated motherboard socket.

The second type is for computer systems that do not have a dedicated OverDrive socket. To upgrade these systems, you must remove the original 486DX processor from its 168-pin socket and replace it with the OverDrive processor.

Because the OverDrive processor runs internally at a faster clock speed, it generates more heat. Therefore, older computer systems may require additional cooling for the new OverDrive processor. You may also have to upgrade the BIOS.

If you're thinking about upgrading your system with an OverDrive, you can get additional information about compatibility by contacting Intel. They maintain an extensive online information network through their own BBS and on CompuServe that lists the compatibility of their processors with many different computers. You can reach them at:

Voice:

Toll free	1-800-538-3373	*Local*	1-503-629-7354
Fax	1-503-629-7580		

Automated Fax Back Line:

Toll free	1-800-525-3019	*Local*	1-503-629-7576

Bulletin Board Service:

503-645-6275 (8-N-1 to 14.4KBPS)
CompuServe: GO INTELFORUM

Generates heat

An OverDrive processor generates a lot of heat. It runs at a temperature of about 180-190° Fahrenheit (80° Celsius). Some of the computer systems are not designed to run with components at such high temperatures. Therefore special fans, customized heat sinks, or other cooling devices are required to keep the heat from damaging other system components.

If you're planning to upgrade your 486 system with an OverDrive processor, contact Intel using one of the above methods to find out more about compatibility and cooling requirements for your particular computer system.

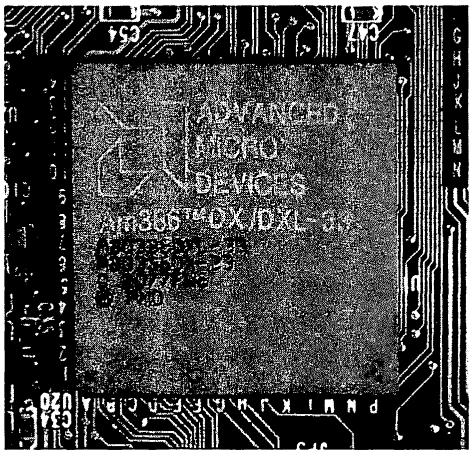
The first OverDrive processors were available as early as 1993. The suggested retail prices (late 1994) for the OverDrive processors are listed in the following table:

Type	Speed	SRP	Type	Speed	SRP
SX	16 MHz/20 MHz	$369	SX	25 MHz	$369
SX	33 MHz	$599	DX	25 MHz	$369
DX	33 MHz	$599			

Remember, these are only suggested prices. Many computer retailers offer the OverDrive processors at discounted prices. Also keep in mind that you may also have to add additional cooling devices to keep the operating temperature down, which will add to the cost of an upgrade. But all in all, the OverDrive processor is a very attractive way to extend your investment in your existing 486 computer system.

Advanced Micro Devices (AMD)

Today many processors made by Advanced Micro Devices (AMD) are being used by computer manufacturers everywhere. Particularly noteworthy is the AMD 386-40 CPU, which is designed for a clock speed of 40 MHz.



The AMD CPU

AMD has their own versions of the 486 processor. AMD's Am486DX is comparable to the Intel 486DX, with math coprocessor and 8K cache. It's available in clock speeds of 33, 40, and 25/50 MHz.

Includes 8K cache

Although AMD's Am486SX doesn't have a math coprocessor, it does have an 8K cache. The Am486SX is currently available in 33 and 40 MHz clock speeds and in two volt versions: 3.3-volt, with power management features required by notebook PCs, and a 5-volt version.

Cyrix

Cyrix makes two families of 486 class processors: Those that have the same socket and pin configurations as a 386 processor and those that are plug-compatible with Intel's 486 processors.

Cx486DRx² and Cx486SRx² Processors - Upgrades made easy

If you're looking for a way to "instantly" turn your 386 computer into a 486 model, this chip will do it. The Cx486DRx² and CX486SRx² look like 386 processors to the motherboard and other components in your computer system, but it runs at twice the speed of the original 386 chip.

When you buy one of these clock-doubled upgrades, you get the processor, chip puller to remove your original 386, software to test you system and enable the 1K internal cache and installation instructions. You can upgrade your computer in about 30 minutes.

Models available and suggested prices are listed in the following table:

Cyrix model for this system	Suggested price
386-16MHz DX	$299
386-20MHz DX	$349
386-25MHz DX	$399
386-20MHz SX	$269
386-25MHz SX	$299

The companion diskette includes a program called CYRXTEST.BAT that lets you determine if one of these upgrade processors is compatible with your 386 computer. You can call Cyrix for additional information at 1-800-46-CYRIX.

Cx486S, Cx486DLC and Cx486SLC/e Processors

Cyrix's other processors are available only to computer manufacturers. The Cx486S has a 2K internal cache memory, but no math coprocessor and uses the same socket as an Intel 486SX.

The Cx486DLC has a 1K internal cache, no math coprocessor and fits in the same socket as an Intel 386DX processor. The Cx486SLC/e has a 1K internal cache, no math coprocessor and fits in the same socket as an Intel 386SX procssor.

Processor	Math coprocessor
Cx486S	Cx487S
Cx486DLC	Cx487DLC
Cx486SLC/e	Cx487SLC/e

Cx486DX and CX486DX2 Processors

The Cx486DX and CX486DX2 each each have an 8K internal cache and built-in math coprocessor. They're plug-compatible with the Intel DX and DX2 processors.

IBM

IBM, through a licensing agreement with Intel, offers their own versions of the 486SX and 486DX chips based on Intel's designs. These chips are not available to end-users but are only mounted on system boards to OEMs.

Blue Lightning

This processor is available in clock-doubled speeds up to 33/66 MHz and a speed-tripled processor (see below) operating at 25/75 MHz or 33/100 MHz; a 40/120 MHz version is soon to follow.

486SLC2

The 486SLC2 is intended primarily for notebooks and other power-saving PCs. It comes in clock-doubling versions with 25/50 and 33/66 MHz speeds.

No math coprocessor

Neither the Blue Lightning or the 486SLC2 include a math coprocessor. However, at 16K, they do feature the largest internal cache memory available on a 486 processor. Both operate at 3.3 volts and use a power management feature.

Speed-tripling processors

If you've followed the discussion about speed-doubling processors, then you'll easily understand speed-tripling processors. A 486 processor with speed-tripling technology executes at three times the normal clock speed.

For some reason, Intel chose to designate clock tripled processors with the suffix DX4. So the standard 486DX-25 processor that operates at a 25 MHz clock speed for both internal and external operations is designated as 486DX4-75 in a clock tripled version. This DX4 executes internal operations at 75 MHz and accesses the outside world at the normal 25 MHz.

Besides the 25/75 MHz version, there's also a 33/100 MHz version of the DX4.

Intel has started to ship OverDrive processors for computers. If these computer systems are designed with the Intel-specified 238-pin socket, most likely you'll be able to upgrade such a DX2 system to use one of the new OverDrive processors. The current (late 1994) line up of DX4 Overdrive processors are 25/75 MHz and 33/100 MHz. The list prices for these are $549 and $649 respectively.

This suggests that Intel has a new Speed Quadrupling technology. Actually, this new OverDrive processor for DX2 systems is part of a family of the next generation chip, the new Pentium processor

The new generation: Pentium processors

History would lead us to believe that Intel's fifth generation processor would be called the 80586 chip. But the next generation chip is here and it's called the Pentium.

Does the name change mean that this new processor represents a revolutionary departure from the performance and compatibility standpoint from the 486's? Not at all. In fact, one of Intel's prime design criteria was to maintain full software compatibility to the earlier generation processors. The name change to Pentium is Intel's way of protecting the name of the processor.

The Pentium is not just a souped-up 486 processor

Has more functions

This is obvious by looking at a single statistic. The 486 chip contains the equivalent of 1.2 million transistors. A Pentium has more than 3 million transistors on board. This tells us that many more functions have been integrated into the Pentium processor.

A computing rule of thumb holds that the more integrated a chip, the faster it runs because the access time is reduced. Putting more functions on one chip means less time spent communicating with outside specialized chips, which would otherwise have to perform those functions.

Intel points to five major areas that account for the Pentium's performance improvements.

1. Superscalar architecture

A 486 processor executes integer instructions through a single instruction pipeline in five discrete steps: prefetch, decode, address generate, execute and write back. When the 486 is executing an instruction, the pipeline is unavailable until that instruction passes to the decode step. Only at that time is the pipeline free to begin another operation on the next instruction.

Two independent pipelines

The Pentium has two independent pipelines called the U-pipeline and the V-pipeline. This means that while one instruction is being operated on through one pipeline, the subsequent instruction can be handled by the second pipeline. Certain classes of instructions cannot be performed in parallel since a subsequent instruction may depend on the outcome of the first instruction's execution. Special circuitry on the Pentium insures that these kind of dependent instructions are properly executed.

A processor having multiple instruction pipelines is termed superscaler architecture. For integer instructions, it's possible to execute two instructions in a single clock cycle. This is responsible for most of the performance gain of the Pentium processor.

2. Processor cache

The time to access main memory is multiple clock cycles longer than to access on-chip memory. To increase speed, the 486 processors all contain 8K of this on-chip cache memory. By keeping a copy of the data and instructions the processor needs in the cache memory, less cycles are used to access the much slower main memory.

The Pentium processor doubles the amount of on-chip memory by providing a separate 8K for data cache and 8K for instruction (sometimes called code) cache. Intel claims that the data and instructions can be accessed immediately from the cache memory 95% of the time, speeding up performance enormously.

3. 64-bit data bus

A 486 processor communicates with the outside world by using a 32-bit wide data bus. This means that 32 bits of information can be transferred from main memory to the processor with each clock cycle. The Pentium has a 64-bit wide data bus. This effectively doubles the amount of information the processor can transfer at once.

The Pentium also has a new burst transfer mode with built-in data integrity checking so information moves faster and more reliably over the data bus. These new features are capable of increasing the data transfer performance by 3 to 4 times over 486 systems.

4. Branch prediction

Any processor spends a large number of clock cycles performing branches. The Pentium uses a Branch Target Buffer (BTB) to speed up branch performance. Here's how it works:

Branch Target Buffer (BTB)

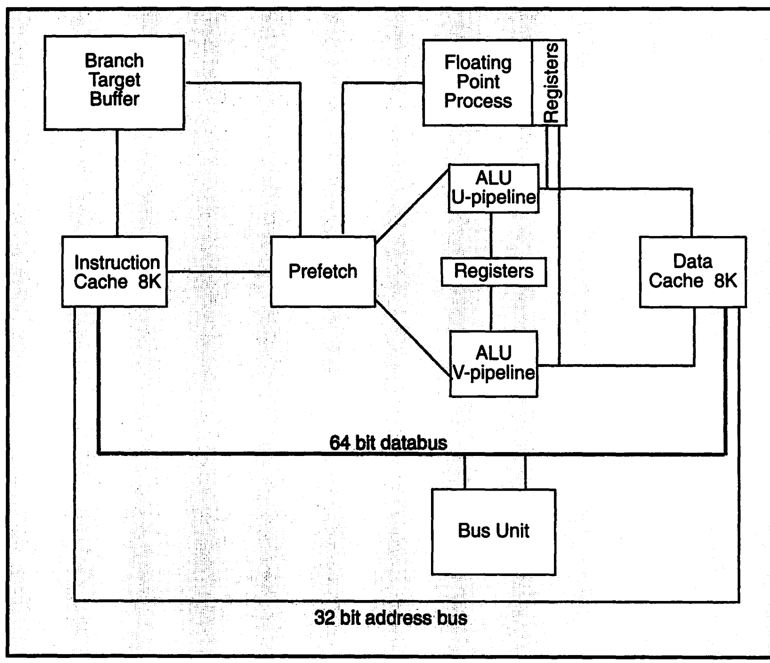
The BTB is actually another small, high speed cache. When a branch instruction is encountered, the instruction and its branch address (the target) are saved in the BTB. In anticipation of a branch, the instruction code at the target address is preloaded into the instruction cache. If the prediction is right, the branch can be made immediately without having to wait for the instruction code at the target address to be loaded.

Intel claims that the BTB can be used to predict the correct branch in more than 90% of the cases.

5. Floating point processing

Many of today's business applications are designed to use the built-in math coprocessor found in 486DX and 486SL systems and the 487SX coprocessor for 486SX systems. Spreadsheets, database managers, computer aided design, numerical analysis, and almost all graphic-intensive applications are speeded up by the floating point processing performed by a math coprocessor.

On the next page is a simplified block diagram of the Pentium processor.



Pentium block diagram

Redesigned floating point unit

In the Pentium, the floating point unit has been redesigned to give much better performance. Many of the floating point operations can be performed in a single clock cycle. Overall floating point operations are improved by a factor of 3 to 5 times.

Pentium computers

To date, Intel has four major versions of the Pentium processor: 60 MHz version, a 66 MHz version, a 90 MHz version and a 100 MHz version.

You may be wondering why there are 60MHz and 66MHz versions of the Pentium. Stuffing 3.1 million transistors onto a cracker-size chip isn't easy. Rather than discarding chips, which cannot pass the rigid quality control standards at 66 MHz, these chips become the 60 MHz versions. The 60 MHz version is fully functional, just not at the 66 MHz clock speed.

Extensive cooling features

The first Pentium computers were delivered in mid-1993. These computers have extensive cooling features:

- Others have an oversize heat sink, a small ceramic or cast metal part mounted on top of the processor. A heat sink absorbs the heat the processor generates and ventilates it into the air inside the case of your PC.

- Others cool the processor by liquid chemicals which cool the chip by evaporation.

All use oversize cooling fans to exhaust the hot air generated by the Pentium processor from the computer case.
One notable characteristic of these new computer systems is that they all use secondary caches. Many have 256K or 512K of secondary cache memory. Using a large, fast cache significantly reduces the time the Pentium must wait for external data thereby taking advantage of the Pentium's amazing processing speed.

Most of these earlier Pentium computers are being designed as file servers. As such, they are equipped to accommodate huge amounts of main memory, fast secondary storage - mostly SCSI class hard drives and a high performance EISA or Micro Channel bus.

Intel is aiming to get Pentium computers on everyone's desktop and has aggressively reduced the prices of these processors. This has narrowed the price differential between a Pentium and DX2-66 systems to as little as $300 in some cases.

With many manufacturers selling Pentium computers at the $2000 price level, it's the new "mainstream" computer.

Performance considerations

You may be wondering how you can determine what kind of computer you'll need.

NOTE

Computer industry publications tend to emphasize the latest developments in the computer field long before they are ready for release. So it may seem as if certain hardware and software is obsolete many months before this may actually happen. Even in the ever-changing field of computers, ground-breaking developments usually occur only about twice a year. So, if you read these publications frequently, don't automatically assume that the predictions are completely accurate.

Consider your applications

When purchasing hardware, many computer users don't consider the application that they'll be using with the hardware. Usually they are interested in only the latest system or the one that's currently on sale. However, the best and most economical way to determine the hardware you need is to consider how the hardware will be used and with which applications.

What hardware do you need?

Once you decide how your system will be used, you can select the appropriate software package. For example, suppose that you'll be using your PC mainly for word processing.

If you want to use Microsoft Word 5.5, a 286 PC is probably sufficient for your needs. However, if you want to use Microsoft Word for Windows 6.0, your PC must meet entirely different requirements. Although you'll be performing the same tasks as with Microsoft Word 5.5 (i.e., creating documents), you'll need a more powerful PC. As its name suggests, Microsoft Word for Windows 6.0 requires Microsoft Windows, and Microsoft Windows 3.1 runs very slowly on a 286. Therefore, you would need at least a 386SX system and Microsoft Windows 3.1, and of course, Microsoft Word for Windows 6.0.

Refer to Chapter 4

As you can begin to see, determining what hardware you need can be a complicated process. We'll discuss this process in more detail

in Chapter 4, System Configuration. The following sections provide some general guidelines.

A 286 PC is suitable for many applications

As long as you'll be dealing mainly with text and simple calculations, a PC system equipped with a 286 CPU will be suitable in most instances. This includes using the computer for business purposes, such as accounting, bookkeeping, inventory, and correspondence.

Some applications obviously place higher demands on the system. This is especially true when the application uses a graphical user interface, such as Windows. In these instances, a 386 or 486 is more suitable.

Increasing performance

System tuning

While you cannot increase the performance of an existing processor, you can tune your system for optimum performance. System tuning includes deleting or reorganizing files and directories, defragging and caching your hard drive and maximizing the amount of unused RAM. We won't dwell on this topic which alone can take volumes.

Replacing the motherboard

There are other ways to increase your performance. For example, you can take your 286AT and convert it to a 386 or 486 by replacing the motherboard. This lets you reuse the other components on your computer: the case, the power supply, the hard and floppy drives, the video card, etc.

However, replacing a motherboard is a very expensive way to upgrade your computer, especially if your trying to increase performance.

For a computer even only a few years old, the hard drive is from a different era and doesn't have the performance characteristics that new class of hard drives now offer. In short, this isn't a very viable way to go.

Upgrading your processor

Another way to boost performance is to upgrade your processor. The Cyrix line of upgrade processors let 386 computer users easily move up to 486 class performance.

By simply replacing the 386 processor on most computers, you can increase a computer's internal performance significantly with an upgrade processor. The cost is a few minutes of work to replace the processor and, of course, few hundred dollars.

Adding a math coprocessor

If the applications that you run do a lot of numerical computations, then you can increase your performance by adding a math coprocessor to you system. Typical applications that do heavy number crunching are spreadsheets, computer aided design and other vector based graphic programs.

Vector graphics and pixel graphics

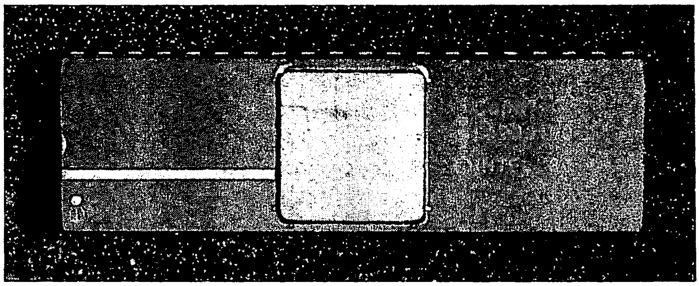
We'll use an example to illustrate the difference between using a coprocessor with vector graphics and pixel graphics. Suppose that you ask a friend to draw a circle of a specific size, on a sheet of grid paper. One way to do this is to specify the coordinates of every point on the circle. Then your friend simply draws each of these points, and the circle is completed.

Pixel-based graphics

This is a pixel-based graphic. Each point is clearly and individually defined. Another way to construct the circle is to specify the coordinates of the circle's center and its radius. Your friend can use this information to calculate the coordinates of the points that comprise this circle. This is an example of a vector-based graphic, since each point is defined only by its relation to the centerpoint and the circle's radius, resulting in a formula (a vector).

Now we'll transfer this circle to the computer screen and try to move the graphic 3 inches (7.62 cm) to the left and 1 inch (2.54 cm) down. To move the pixel-based graphic, it's only necessary to shift information in video RAM. Since this is a task that the CPU can perform easily, a coprocessor isn't needed.

However, to move the vector-based graphic, the coordinates to every point on the circle must be recalculated because its centerpoint is being moved. In this case, a coprocessor would be very useful because this task requires the CPU to perform numerous fractional operations.



A mathematical helper for a 286

Why a math coprocessor

As the number of floating point operations that are required increases, the more a mathematical coprocessor will increase your system's performance.

286 and 386 based computers have a math coprocessor socket on the motherboard. By adding an appropriate model math coprocessor you can speed up these kinds of applications immediately. Math coprocessors are manufactured by Intel, AMD, Cyrix, ITT and USLI and are compatible with almost all CPUs and simply plug into the math coprocessor socket.

On some versions of the 486 processors, a math coprocessor in already integrated into the chip. For these 486's there is no need for a math coprocessor socket. However, other versions of the 486 processor, for example the 486SXs, do no have a built-in math coprocessor. So you can speed up math intensive applications by adding an appropriate math coprocessor to these systems also.

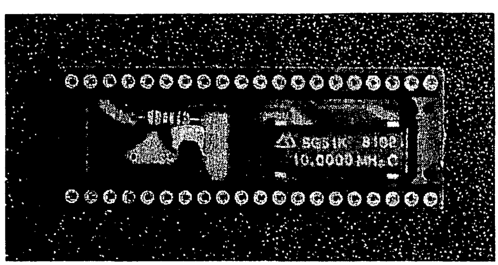
One company that specializes in a high performance math coprocessor is Weiteck. These coprocessor are designed to boost the performance of AutoCAD, a computer aided design application and several other math intensive applications that are especially written to use the Weitek. The Weiteck coprocessor are significantly faster than standard math coprocessors and it's nice to know that you can look for another solution if you need the this kind of performance gain.

This type of upgrade is very worthwhile if you intend to keep your computer for another year. Most math coprocessors can be purchased for $50 to $75 from your local dealer or computer store.

Using a fast socket

If you're a real number cruncher, and you use a 286 computer, then you even have a way to speed up your math coprocessor. The 80287 coprocessor operates at only 2/3 of the CPU's clock speed.

This can be boosted by inserting a "fast socket" into the motherboard's coprocessor socket. A coprocessor chip is then plugged into the fast socket. This turbo socket contains its own quartz clock, which operates independently of the system clock.



A fast socket equipped with its own quartz

Turbo sockets are available in all 286 frequencies. However, the coprocessor that will be used with the socket must be designed for the corresponding clock speed. This requirement remains the same. Using this device to make your coprocessor noticeably faster than your CPU won't work, because an extremely fast coprocessor must still wait until the CPU is ready to receive the results.

This upgrade will work only with 286 motherboards, since 386 and higher coprocessors operate at the same clock frequency as their CPUs.

The bus system

You can think of the system bus as your computer's mail system. The bus handles the delivery of information between the CPU and the other devices in your computer system.

The system bus connects your CPU to the computer's main memory (system memory). The expansion bus, which is an extension of the system bus, also connects the CPU to all of the expansion cards. This makes the bus the central component for coordinating the communication among various devices in the computer.

When you want to display characters on the screen, the CPU puts those characters on the bus and informs the video display card that they're available. The video display card can then "pick" those characters off of the bus and send them to the monitor. All the while, the CPU and video display card are coordinating the operations using the bus signal lines.

If you think that the performance of the bus can have a major impact on the overall computer system performance, then you're absolutely correct.

What makes up the bus?

The system bus is basically a collection of wires or circuits. We can divide these circuits into three different groups: the data bus, address bus, and the control bus.

The data bus is the path over which data is transferred between the CPU and another device. For the original IBM-PC, this path was 8-bits wide. This means that the CPU can transfer 8-bits or one byte at a time over the bus. Later, the PC-AT bus was widened to 16-bits to better utilize the 16-bit capabilities of the 80286 processor. Today, the EISA, MCA, VLB and PCI ;buses have data paths which are 32-bits wide.

Regardless of the width of the data path, the CPU cannot simply send the data over the data bus. First, it has to specify where the data is to be sent. The address bus is used to communicate this information. To transfer data to a sound card, for example, the CPU puts the sound card's port address on the address bus, and then puts the data onto the data bus.

The last sub component of the system bus is the control bus. As its name suggests, this set of circuits ensures that the communication among the devices proceeds and concludes in an organized and controlled manner.

The control bus gives individual components access to the address and data buses. The circuitry of the control bus prevents bus operations from colliding or overlapping and that the data is sent to the proper locations.

Increasing the bus speed

The speed and width of the bus have a direct impact on a computer system's performance. Recall that 286 and 386SX CPUs use a 16-bit bus. But 386DX and 486 CPUs use a 32-bit bus.

Unfortunately, it's not possible to change the data width of a CPU. However it is possible to increase the speed of the system bus. In some computer, the BIOS setup, such as AMI BIOS, lets you select from among several different bus frequencies.

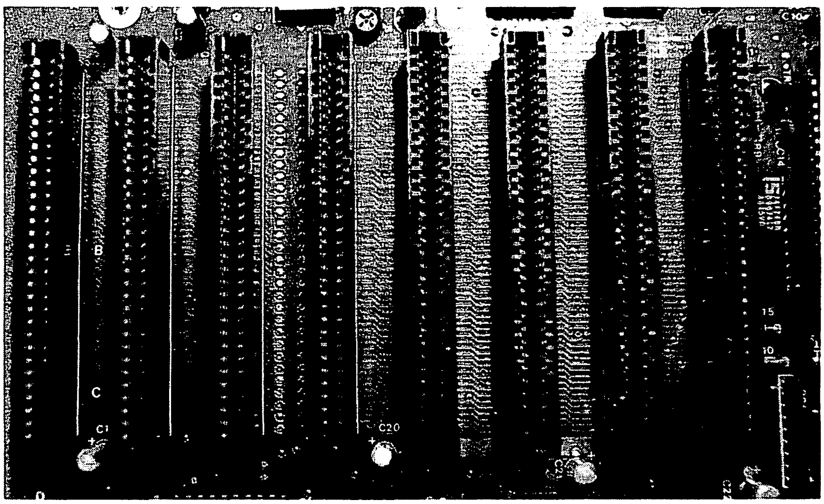
The original IBM-AT bus run at a speed of 8MHz. Although this is still a standard today, many expansion cards are capable of working at a higher speed.

If your system has such a BIOS, you may want to increase your bus speed to 10 or perhaps 12 MHz. This can give you a marked improvement in your video display card performance and some hard disk transfers.

Some older hard disk controller models however, may have problems handling the increased transfer rate. Older MFM controllers, such as the WD 1003, frequently produce write errors. Carefully test your computer system if you plan to boost the bus speed.

Expansion slots

The expansion slots are basically the access sockets to the bus system. Through these the bus is able to connect with expansion cards, such as video adapters and hard drive controllers. Expansion slots don't always have to include all connectors of the bus system. So you'll often find 8 or 16-bit expansion slots on a motherboard with a 32-bit CPU. You'll find these slots on the left and toward the rear of your PC's motherboard.



The 8-bit slot of an XT system

Expansion slots are long, black plastic sockets. Some of these slots probably already contain expansion cards. The shorter one-piece sockets are the 8-bit slots, and the longer two-piece sockets are 16-bit slots. Sometimes you'll also see one particularly long or differently configured slot. Such slots are used for memory expansion cards, which are usually equipped with a 32-bit bus on 386 and 486 motherboards.

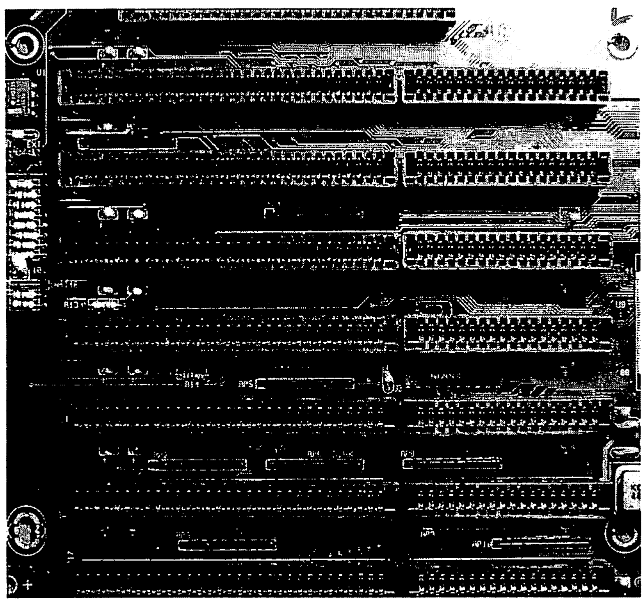
Now we'll examine the different expansion bus systems.

ISA bus (open system)

ISA is an acronym for "Industry Standard Architecture". Usually when someone refers to the industry standard or the ISA bus, they're speaking of the 16-bit wide AT bus. However, this

definition of the term isn't entirely correct, since it was widely used during the days of the IBM XT.

The standardized expansion slot of the XT was one of the main factors that made the XT, and its descendants, so successful. This feature was the key element in the computer's open architecture. This design allowed the PC to be adapted to special applications through the use of expansion cards. In addition to the 20-bit address bus, this slot was equipped with only an 8-bit data bus. Because of this, it's quite limited by today's standard.



The 16-bit slot of an AT system

This changed in 1984, with the arrival of the AT bus, which represents the first revision of the industry standard. The AT bus is fully compatible with the 8-bit XT bus. An additional socket containing 8 further data bits, as well as additional address bits, was simply added to the 8-bit XT bus. So the AT bus consists of a two-piece slot with 16 and 24 data bits.

In addition to these 16-bit expansion slots, most motherboards are also equipped with one or two additional 8-bit slots. The reason for this is simply the manufacturer's thriftiness, since 8-bit expansion cards can also be used in any 16-bit slot.

With an operating frequency of 8 MHz, the AT bus reaches a data transfer rate of up to 6.5 Meg per second. Most expansion cards cannot even use this rate.

Because 32-bit CPUs are being used more frequently, bus systems with an even higher data transfer rate are needed.

EISA bus

EISA is an abbreviation for "Enhanced Industry Standard Architecture". The EISA bus is an enhanced version of the AT bus. This new standard has been developed by the leading computer manufacturers (except for IBM) to meet the higher performance demands created by 32-bit processors.

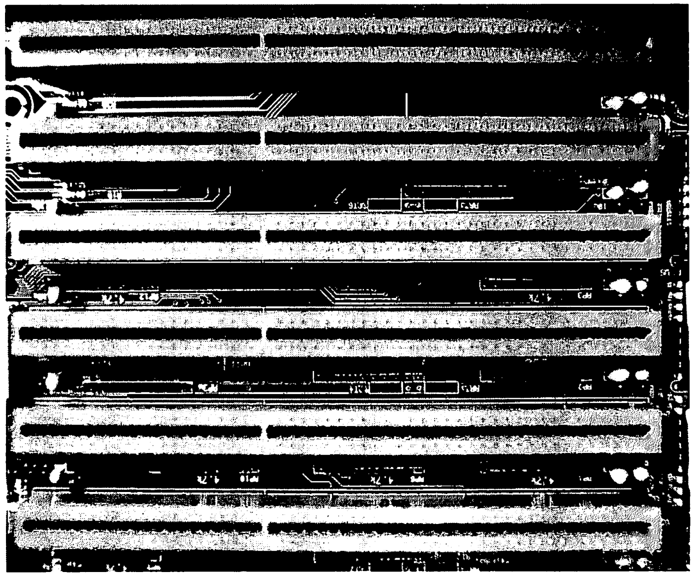
True 32-bit bus

Since the EISA bus is a true 32-bit bus, all 32 data bits of the CPU are also present in the expansion slot.

The high data transfer rate attained through this expansion isn't the only advantage of the ISA bus. A more significant, but rarely used, advantage is that the EISA expansion slots are capable of "multimastering."

This means that several processors are able to access the same bus simultaneously, so a parallel-processor system could easily be created by inserting a CPU expansion card into the EISA slot.

Another advantage of the EISA system is that it's fully compatible with the ISA bus. This means that you can use any old expansion card in the new EISA slots. These cards won't run any faster on the new slot. However, in most cases, this won't matter because many cards, such as printer interfaces or floppy controllers, don't need to run faster.



The 32-bit slots of an EISA board

The increased performance of the EISA bus is most noticeable with graphic applications that use extremely fast EISA video adapters. These allow data transfer rates of up to 32 Meg per second, which is almost five times the rate attainable by the old AT bus.

TIP

When selecting or implementing special EISA hard drive controllers, you should remember that only a few hard drives are capable of even reaching such high data transfer rates. If you want to increase hard drive performance significantly over an optimized ISA system, you'll need to install a large (multiple Meg) cache controller.

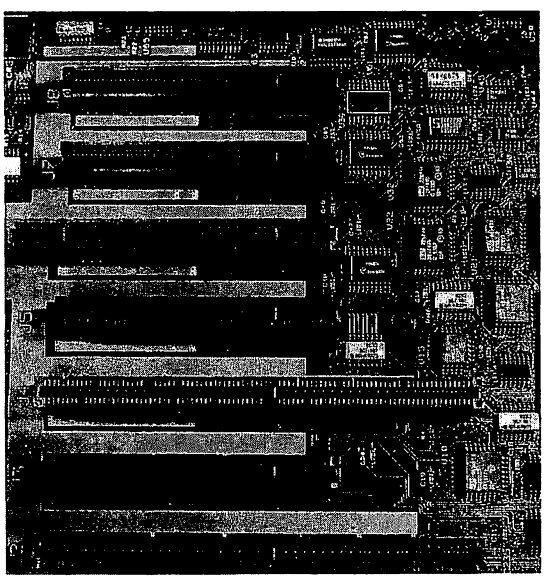
So, if you aren't going to need a fast graphics workstation and you won't be using your PC in a high performance network, you shouldn't purchase an expensive EISA board.

MCA bus

IBM developed the MCA (Micro Channel Architecture) bus to be a high performance data bus for the PS/2 generation of personal computers. Using this system, data is placed on the channel and the intended receiver, say a video card, is granted access to the channel and can retrieve the data.

The CPU isn't involved, so transfer rates as high as 20MB per second are possible. Also, since the MCA bus allows for "smart peripheral", much of the overhead of data transfer can be offloaded from the CPU thereby freeing it up for other tasks.

The MCA bus has not been an overwhelming success. One reason, is that peripherals for MCA are more complicated, and therefore more expensive. Another reason is that MCA expansion cards and peripherals are incompatible with those for the ISA bus, older devices cannot be substituted in these computers. Since IBM licenses the MCA technology to third party peripheral makers, there is also this additional expense.



The slots of a PS/2 motherboard

TIP

If you're considering purchasing such a system, you should carefully weigh the performance advantages of the MCA bus against the limited expansion options. Even other changes to the PS/2 system, such as installing a 5.25-inch disk drive or a larger hard drive, can be very expensive.

VESA local bus

One drawback of the ISA and EISA buses is that they typically run at a speed of 6 to 8.33 MHz. Furthermore, the ISA is limited to a 16-bit bus width.

To transfer data to a peripheral, the CPU gets the data from system memory, puts it on the bus, lets the peripheral know its ready and then waits until the peripheral has retrieved it. You can see that there's a lot of steps and overhead involved in I/O operations over the bus.

To transfer 32-bits on information over a 16-bit bus requires two accesses to the bus. From this, you can see that a 486-33MHz CPU with a 32-bit processing capability could overwhelm one of these buses.

The VESA Local Bus (VLB) is designed to overcome the bottleneck created by the difference in processor speed compared to the difference in which data moves between the processor and a peripheral.

A system with VLB can access 32-bits of system memory directly at the speed of the processor. With a peripheral designed for the VLB, data transfer can take place without the intervention of the CPU at a blazing speed.

This represents a tremendous improvement in throughput to any periperhal capable of handling the additional data.

The most common use of the VLB is accelerating the video display. A new generation of video cards are VLB compatible and can redraw 30 million or more pixels per second. With Windows and OS/2 GUIs, this gain can make a remarkable difference in performance.

Other expansion cards now are now becoming available for the VLB such as hard drive controllers that will be able to improve the performance of these peripherals as well.

PCI local bus

An alternative to VLB is the Intel-designed PCI (Peripheral Component Interconnect) local bus. In most respects, this bus is similar to the VLB. It supports 32-bit access to system memory and transfers data at roughly the same speed as VLB.

On the downside, adapter cards and peripherals must be redesigned to take advantage of the PCI local bus. Like MCA, this makes them more expensive.

One big boost for the PCI local bus is that Intel has been able to push this new bus in parallel with its Pentium processors. A PCI local bus runs at the same 60 MHz or 66 MHz as the processor itself.

Also, it's capable of accessing the Pentium's full 64-bit width. As the Pentium makes it into more PCs, we'll probably see the PCI there as well.

Main memory (RAM)

The motherboard contains another integral component of every PC system. The main memory, like the CPU, is essential to the operation of the PC system. Even the operating system, which is needed to execute a program, needs this memory to be loaded.

Main memory acts as a type of "short term memory" and is often referred to as RAM (Random Access Memory). The CPU uses this memory to perform its current tasks. The contents of main memory are changed and updated, as needed, while the processor is working.

Different program sections are frequently read from the hard drive and stored in memory while the program is running. Main memory consists of temporary memory, because all the information stored there is lost when the computer is switched off. However, mass storage devices, such as hard drives and diskettes, are capable of retaining information permanently.

Today personal computers have 2 to 8 Meg of main memory, depending on their CPU class. Not long ago 640K was the standard size for the main memory of a PC. So, at that time, 1 Meg was considered an incredible amount of memory.

In the following sections we'll discuss the various parts of the PC's main memory.

Memory chips

Approximately 12 different types of memory chips are used in today's personal computers. These chips are combined in different ways, depending on the size and scope of the particular main memory.

The compatibility with a given motherboard is determined by the sockets on that board. The chips are simply plugged into these sockets. So, the soldering iron, which was used for memory expansions years ago, is no longer needed.

The different chips used for main memory can be divided into two groups: DRAM (Dynamic RAM) chips, and SIMM (Single In-line Memory Module) or SIP (Single In-line Packages) modules. The difference between these two groups is easy to explain.

While dynamic RAM chips consist of individual single-chip elements, several RAM chips are grouped into a single element in SIMM or SIP modules. So, SIMM or SIP modules are simply a group of RAM chips that have been soldered together to form a single component. We'll discuss these in detail later.

Dynamic RAM chips

Dynamic RAM chips are located in small black chip casings, with prongs protruding from their longer sides. The chip is connected to the rest of the system by these prongs. Depending on the capacity of a chip, it will have 16, 18, or even 20 prongs. Chips are available in capacities of 64 kilobits, 256 kilobits, and even 1 megabit, and usually contain corresponding inscriptions (4164, 41256, and 411000 or 411024, respectively).

Recently a special version of RAM chips, which use a quadruple bit structure, is becoming more popular. These chips have four times the storage capacity of a normal 1-bit chip and are available as 464, 4256, and 4400 models.

However, you don't have to worry about the designations of RAM chips. With a little practice, you'll be able to determine a RAM chip's capacity by the number of prongs on the chip (64 and 256 kilobit chips have 16, 464, 1000 kilobit chips have 18, and quadruple bit chips have 20) and the last three to four digits inscribed on the chip casing.

This type of RAM chip is called "dynamic" because its memory contents must be refreshed continually. This means that these chips constantly undergo a refresh rate. This is simply the nature of these components, because the actual storage elements consist of only capacitors, which can either be charged or discharged. Since such an element can take on one of two states, it corresponds to the value of one bit. So one capacitor is needed for each bit.

For example, a megabit chip capable of storing precisely 1,048,576 bits of information contains over one million capacitors. However, such a capacitor loses its charge after a short time. To retain the information stored in the chip for more than this discharge time, it's necessary to read the status of the chip's capacitors and recharge them. This results in the mentioned refresh rate.

The information stored in a chip cannot be accessed while the chip is being refreshed. Since the intervals between each refresh vary for different types of chips, you can select between "faster" and "slower" RAM chips. Access times for RAM chips are specified in nanoseconds, and usually range from 70 ns to 120 ns. The higher the access time, the slower the chip.

Bits and bytes

As we mentioned, these chips come in capacities from 64 to 1024 kilobits. However, a PC's main memory is assembled in kilobyte segments. As you may know, eight bits make up one byte. Therefore, eight chips of 64 kilobits each is equal to 64K of memory. RAM chips are grouped in rows of nine elements each.

Eight of these elements are used for storing the actual data bits. So they can store between 64 and 1024K, depending on the type of chips used. The ninth chip acts as the control element and is responsible for performing the parity check.

During operation, the remaining chips continually produce a checksum, which is then checked against the parity bits stored in the ninth chip.

The three-chip approach

At first the quadruple chips mentioned above, of which the 4x256 kilobit chip is most often used in PCs, may seem to be an exception from the method of grouping nine chips together. However, it's easier to understand if you imagine the quadruple chip as simply four individual 256 kilobit chips.

A row of 256 kilobit chips can consist either of nine individual 256 kilobit chips or of two quadruple 256 chips together with a single 256 kilobit chip (2x4+1=9), which is a total of three chips.

In this way, a complete row of chips occupies only one third of the space because only three chip sockets are needed instead of nine, even if the quadruple chips have two more prongs on each side than the regular 256 kilobit chips.

SIP and SIMM modules

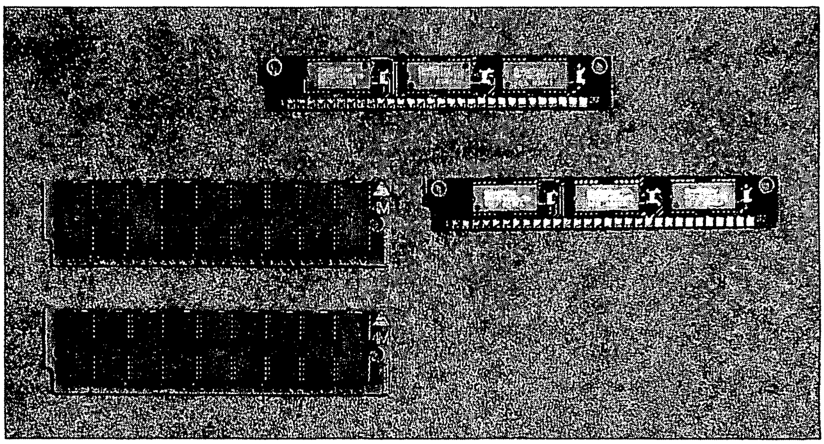
SIP and SIMM modules were developed as a result of computer applications continually requiring more memory. Each module corresponds to a complete row of memory chips.

More memory through space-saving technology

Since the amount of area occupied by such a module is considerably smaller than that used by the conventional DRAM sockets, significantly more memory can be installed on the motherboard.

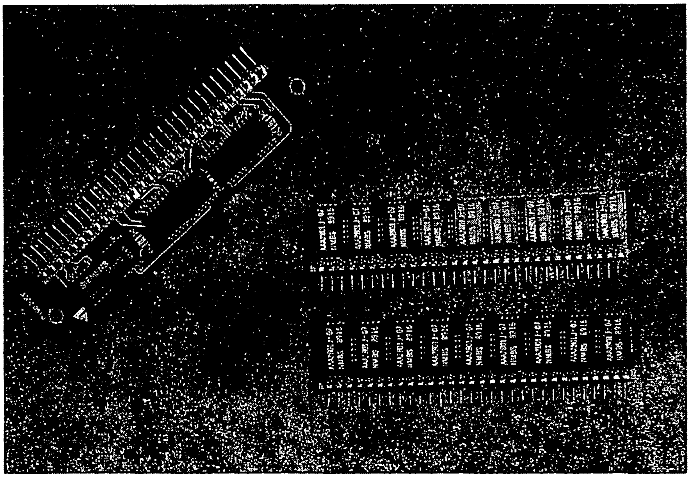
These modules are available in 9-chip and 3-chip arrangements; the 3-chip arrangement seems to be the more popular arrangement. However, all motherboards aren't compatible with this technology.

It's possible that memory problems or even parity error messages will occur because the board isn't compatible with the 3-chip module. These memory modules are available in 256K, 1 Meg, and 4 Meg capacities.



SIMM modules

SIP modules (Single In-line Packages) have a row of 30 small prongs which are inserted into a corresponding socket strip. SIMMs (Single In-line Memory Modules), however, use a type of contact strip similar to the ones used on expansion cards. So SIMMs are inserted into wrap or snap connectors.



SIP modules

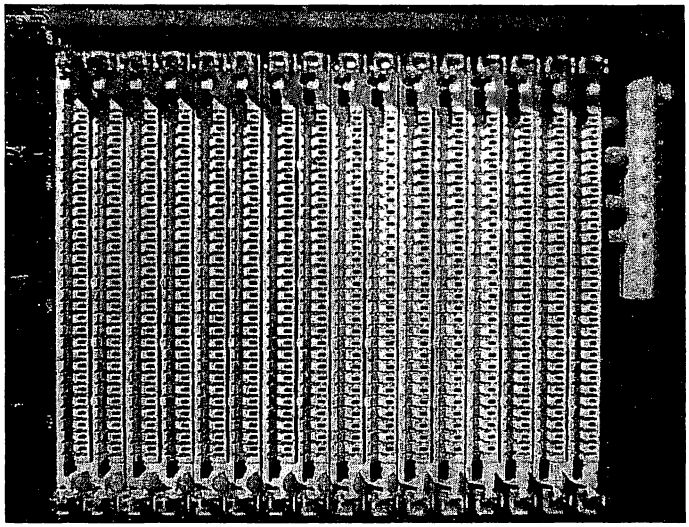
The two memory banks

Regardless of which type of memory elements are actually used, the memory located on PC motherboards has been organized into two memory banks since the 286 PC generation. The first is designated as "Bank 0" and the second is designated as "Bank 1".

Since it's usually possible to install several different types of memory chips, the size of a memory bank ultimately depends on the types of chips used. Older 286 boards can thereby be equipped with a maximum of either 1 or more Meg of RAM, depending on whether 256 kilobit chips or 1 megabit chips are used.

The motherboards of high speed 386 and 486 PCs almost always contain SIMMs. When 4 Meg modules are used, memory capacities of 32 Meg "on board" can easily be attained.

This is possible because a memory bank generally includes 4 sockets; so a total of 8 sockets can receive SIMM modules. Some boards even contain 16 such sockets, so a maximum of 64 Meg of on board RAM can be installed.



SIMM sockets

Combining different memory chips

Only memory chips of equal capacity can be used within the same memory bank. However, chips of different access time are allowed. Memory access will simply be conducted with reference to the weakest chip in the system. Although chips from different manufacturers can also be mixed within a memory bank, occasionally problems can occur.

Restricted mixing and combining is possible

Using memory chips with different capacities between the two memory banks of a motherboard isn't always permitted. For more information, refer to the documentation included with your motherboard.

Memory management

We mentioned the correlation between processor generations and addressable memory when we discussed the different PC processor generations earlier in this chapter. During the past eleven years the physical memory limit has been increased dramatically. As a result, the amount of memory that can be addressed by these processors has grown from 1 Meg to 4 gigabytes.

Whether it's a 386 or 486, the current high-speed PC systems are downwardly compatible with the original IBM PC from 1981, which was based on the 8088 CPU. This means that all generations of PCs are still capable of operating in the same mode as the original PC. They are also using the same operating system.

Although this operating system is in its fifth generation, it still forces these modern PCs to work much below their potential. In addition to compatibility to the 8088 and the use of DOS, PC memory management is another problem of today's PCs.

The 8088 divided its addressable memory into a segment for the operating system and application programs (a maximum of 640K main memory) and another segment of system memory or controller memory. The latter portion contains address segments for the video adapter, the system BIOS, and other hardware components.

This system memory was set at a size of 384K, which results in a total of 1024K or 1 Meg of memory. This completely used the entire memory range addressable by the 8088 CPU.

System memory (ROM)

As we mentioned when IBM developed the PC, the memory segment between 640K and 1 Meg was reserved for system use. This address range has since been used as ROM (Read-Only Memory). So, unlike RAM, you can only read from ROM, and not write to it.

The term "ROM" actually no longer applies to every portion of system memory. However, the term still implies that this entire address range is controlled by the system. So, this memory is hardware controlled, and cannot be used by external software under any circumstances.

This applies to the different BIOS systems that can be resident in a PC. Each motherboard is equipped with a main or system BIOS, also called ROM BIOS. The system BIOS is located in the upper portion of system memory. The uppermost 64K, below the 1 Meg boundary in every PC, are reserved for this purpose.

Address conflicts

A 192K address segment, which is reserved for adapter BIOS systems used in IBM compatible PCs, is located directly below the system BIOS segment. These can include EGA BIOS or VGA BIOS,

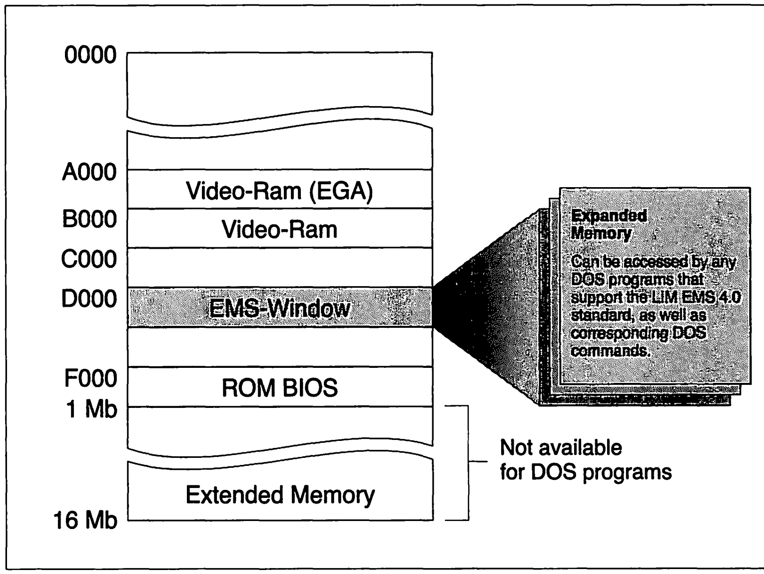
as well as the BIOS for a SCSI hard drive controller. Network cards must also be addressable through a specific ROM address.

If several expansion cards in your system require their own BIOS, this reserved memory segment can quickly become too crowded, which leads to addressing conflicts. You should consider this possibility before purchasing such hardware. Many expansion cards feature user-selected BIOS addresses, so address conflicts can be avoided.

You should be aware that original IBM PCs are equipped with a ROM BASIC, which automatically runs if the PC fails to locate an operating system that can be loaded into RAM at bootup. This ROM BASIC occupies 64K of the memory segment otherwise reserved for the adapter BIOS systems. When this occurs, the segment size decreases further.

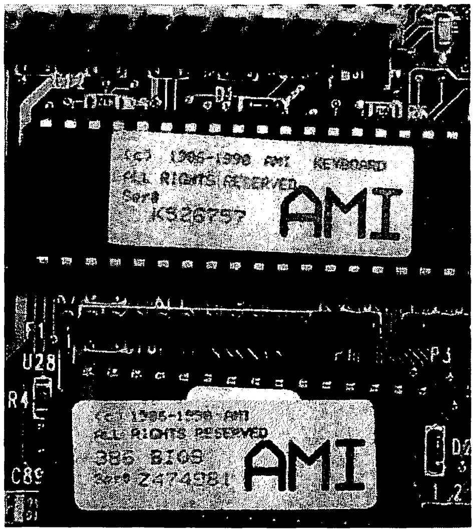
The memory segment reserved for video RAM, with a total size of 128K, is located below the address segment for the adapter BIOS systems. This memory segment uses the remainder of the entire 384K of memory reserved for the system. Remember that we're discussing only address ranges and not the information that's actually stored in these memory locations.

Instead of memory capacities, the memory sizes listed above represent addresses at which the CPU can access the corresponding memory locations. Except for the video RAM and the EMS window (see below), these memory addresses can be accessed with one read operation.



Expanded and extended memory

Physically, the memory contents represented by these address ranges are stored on, for example, the video adapter (video RAM and, where applicable, video BIOS). As we mentioned, the system BIOS is located on the motherboard, while other BIOS systems are located on their respective expansion cards. A BIOS is stored as a program routine on one or two EPROM chips.



EPROM chips containing the BIOS

EPROM is an abbreviation for "Erasable and Programmable Read Only Memory". These ROM chips can be programmed using special equipment outside of the PC.

EMS window

Depending on the number and size of adapter BIOSes and the potential presence of ROM BASIC, a contiguous memory segment of at least 64K will remain within the address range described above. According to the Expanded Memory Specification (EMS), which was created by Lotus, Intel, and Microsoft (LIM), this memory segment can be used by the operating system and its applications to access additional memory pages through the support of a special EMS driver.

RAM shadow principle

As you can see, none of the memory bytes from the installed RAM chips are used by the PC's system memory. Physically, as well as in reference to its address range, system memory is completely segregated from the PC's main memory. Because of this, the capacity of the RAM chips installed on a motherboard can be fully allocated as main memory.

Shadow option

In modern PCs, CMOS SETUP often allows you to install a shadow RAM. This option allows the BIOS information usually found in system memory to be copied to RAM, or main memory. A shadow of the permanent BIOS is created in RAM. This enables the CPU to access BIOS information more quickly because RAM access is considerably faster than ROM access.

This shadow option for both the system and video BIOS is usually a default setting on most PC BIOS versions. The AMI BIOS provides the user with detailed shadow allocations for the entire address range of system memory, so adapter BIOSes can be copied to RAM in addition to the system and video BIOS.

To use such a shadow BIOS, you must reserve a corresponding memory segment within physical RAM and define it as a shadow memory segment. Remember that a physical portion of main memory must be reserved and specifically allocated to receive the BIOS information. This portion of memory will be used for this purpose only. So the available main memory is reduced by the size of the reserved shadow segment.

Shadow RAM reduces available RAM

The re-allocation of main memory to shadow RAM isn't always performed the same way. There are various ways to do this; each of these methods affects the remaining main memory differently.

With modern 286 BIOSes, usually an activated shadow option automatically subtracts 256K from the system's main memory, regardless of how much memory is actually required for the RAM shadow. This means that at a total memory capacity of 1 Meg, for example, the amount of available extended memory would decrease from 384 to a mere 128K.

Many 386 and 486 BIOS versions will reserve 384K of the RAM installed in the system, regardless of whether the shadow option is activated. So 4096K of installed memory, for example, would be reduced to 640K of conventional memory and 3072K of extended memory. However, other systems will reserve only the amount of memory from RAM that is actually required for the ROM shadow.

Shadow RAM increases speed

Activating the shadow option will increase system performance. This increase will be noticeable with 386 and 486 systems. However, particularly with 286 systems, the advantage of increased speed may not be worth the resulting decrease in main memory capacity.

NEAT chip groups permit remapping

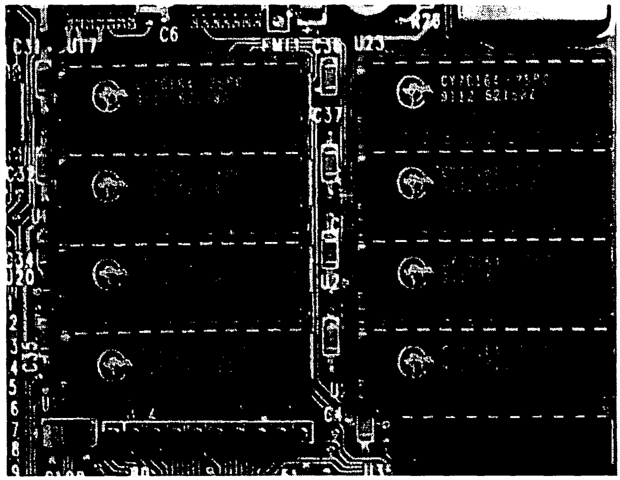
In a few cases, primarily with boards using NEAT chip groups, expanded CMOS will offer the option of RAM relocation, which is also referred to as the relocate option or remapping. This option makes it possible to reallocate the memory, which has been reserved from RAM as shadow RAM, back to generally available main memory, if the shadow option isn't activated. Although this is an awkward procedure, it's quite useful for 286 systems with a limited amount of RAM.

Cache memory

Many of today's processors can operate at clock speeds of 25 to 33 MHz and more. As a result, PC main memories consisting of dynamic RAM chips are no longer able to keep up with the fast access times of these CPUs. At these clock frequencies, the processor is forced to spend half of its time waiting for RAM, which usually means that the processor's capabilities cannot be used effectively.

External cache

To solve this problem, the entire main memory should be physically replaced by static RAM chips, which permit much shorter access times. However, this solution would be too expensive. Therefore, a method, which had already been used in the 1960's on large-scale systems, has been applied in high-speed 386 and 486 PCs. This method involves installing an external RAM cache buffer. In this case, "external" means outside of the CPU, so the cache is connected with the processor through the bus system.



Static RAM chips of the external cache buffer

On i486 motherboards this external cache is also referred to as the second level cache, since it exists in addition to the integrated cache of the i486 chip and is located outside the CPU on the motherboard. It consists of a row of static RAM chips of either 64 or 256 kilobit capacity. This results in a cache of either 64 or 256K, which is actually a small amount of memory when compared to main memory. The 82385 cache controller from Intel manages this cache.

The principle of RAM caching

The RAM cache is located between the CPU and the system's main memory and acts as a buffer. Since IBM compatible PCs execute their instructions sequentially, good programs are written according to the "locality principle." This means that as many identical or neighboring memory locations will be accessed during program execution as possible. Program jumps to more distant memory locations (far jumps) are generally avoided.

For a program loop that's executed several times, the same command must be retrieved from memory continually. When the CPU accesses a certain memory location, the contents of that address range, and at least the neighboring address range, are written to the cache and then passed to the CPU.

If an effective programming technique is used, the CPU's next memory access should occur in the same or the neighboring address

range. So, in most cases, the required information can be obtained from the cache. Otherwise a normal RAM access operation is performed.

This method optimizes the CPU's access to main memory. During operations that require information that's currently stored in the cache (cache hit), faster CPUs are used more efficiently. Only after cache misses is the CPU forced to access the comparably slower main memory banks.

Different manufacturers of PC motherboards use different caching strategies. These differences involve which data is stored and found, and how the cache contents are further used. The method by which information is copied from main memory to the cache may also differ. The size of the cache is another important factor.

The difference in the performance of two PCs with equally fast motherboards, one with an external cache and one without, will be dramatic. This difference is even obvious with 386SX motherboards.

Cache size affects DOS

For a PC operating under DOS, a cache size of 64K is a sufficient and ideal amount. Comparisons have shown that under DOS even a 486 PC, for example, became slower depending on the cache size used. This test showed that system performance under DOS was reduced by about 10% when the external cache was increased from 64 to 256K. However, under OS/2, the same cache upgrade led to a noticeable increase in performance.

The motherboard's chip set

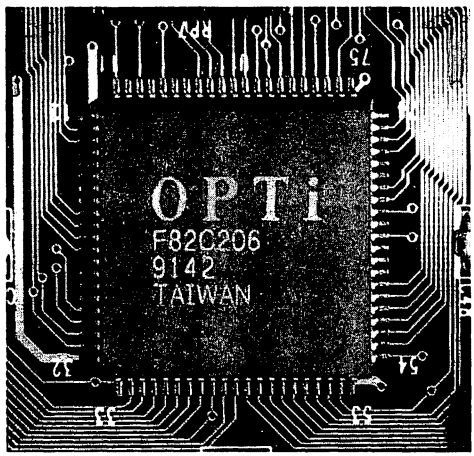
Now we'll discuss the final component of PC motherboards that's involved in processing information.

The motherboard's chip set consists of highly complex and coordinated ICs that help the CPU manage and control the PC system. Among other things, these chips help the processor organize its access of RAM, as well as the data and address buses.

Incompatibilities

Several chip sets are available for PCs. They are usually soldered permanently to the various motherboards. Some well-known

manufacturers of these chip sets include Chips & Technologies, Symphony, Opti, UMC, and VLSI. Since there are so many manufacturers, we cannot list all the differences between each of these chip sets.



An Opti chip set

System problems

Frequently incompatibilities between certain chip sets and other hardware components lead to problems within the system. For example, we've encountered problems with 486 boards, equipped with Forex chip sets, working with several video adapters, such as Diamond and Speedstar HiColor. However, other video adapters, even with identical specifications, ran flawlessly. So remember, incompatibilities between hardware components are often related to the chip sets used on a motherboard.

NEAT chip sets, which are used primarily on 286 boards, have also been installed on 386SX motherboards. The abbreviation NEAT stands for "New Enhanced Advanced Technology;" Advanced Technology refers to the AT model equipped with a 16-bit bus.

This chip set consists of a bus controller (82C211), a memory controller (82C212), a data and address buffer (82C215), and a peripheral controller (82C206). On 386 motherboards these chips have slightly different designations (82C811, 82C812, 82C815, and 82C806), but perform basically the same functions.

Page interleaving

These chip sets offer an expanded SETUP function that permits bitwise programming of the PC's control registers. Among other things, this makes it possible to select a method of memory addressing that permits quick switches between the two memory banks, as long as both of the PC's banks are being used. While one memory bank is being refreshed, the other bank can be accessed. This results in an increased memory access rate.

Used by many manufacturers

This method, which is called page interleaving, is used by many chip set manufacturers, such as Opti. Remember that determining the correct CMOS setting of NEAT chip sets can be very complicated. So, you should use the default settings unless you're familiar with the possible settings and their respective functions.

Non-NEAT chip sets can also be manipulated through expanded or special CMOS chip setups. In Chapter 8 we'll discuss the various settings by using an AMI BIOS as an example.

However, in most cases the chip sets of modern motherboards are already set up optimally for standard operation and won't require any setting changes.

2.2 Storage

In this section we'll discuss the next function area within the PC system. This area involves the components that are responsible for permanently storing the information that will be processed. The component groups and devices that are included in this process can be considered peripherals of the PC system.

However, the term "peripheral" now refers to any device that is physically located outside the actual PC, such as printers or scanners.

Therefore, mass storage devices, which we'll discuss in the following sections, are technically peripherals that are connected to the bus system through interfaces (usually expansion cards). The data exchange between the CPU and the storage device then takes place through this interface.

Constantly rising demands

The amount of data that we process on a daily basis is constantly increasing. So personal computers, which are designed to help us process information more effectively, are also confronted with an ever-increasing flow of data. The demand for user-friendly programs has also increased the size of programs. As a result, the demand for high-capacity, high-reliability, and high-speed mass storage devices has also increased drastically.

When information is stored, it is not only deposited but also retrieved as quickly as possible. This depends on both the way in which data is organized on a particular data carrier, and the data transfer rate of a particular storage medium. In the following sections, we'll give you an overview of the possibilities and limitations of modern storage devices. We'll also discuss some of the innovations that may occur.

Disk drives

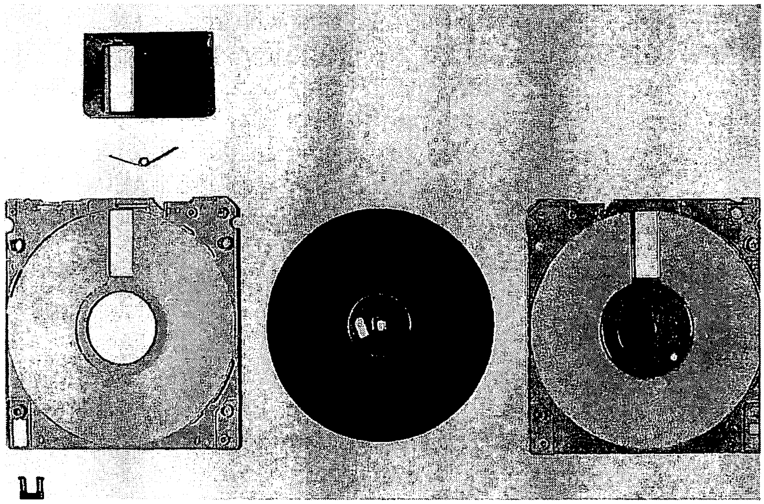
The oldest and probably most common mass storage device used in PC systems is the disk drive, or floppy disk drive. This type of drive uses a removable data carrier. So, the drive and data carrier are separate components. This means that disk drives in one of today's formats (3.5-inch or 5.25-inch) are able to access different diskettes.

Diskettes are still one of the most important storage media used with PCs. Software is stored and sold on diskettes, data backup is usually performed on diskettes, and information between two PCs is even exchanged by using diskettes.

The data carrier

Ultra-thin coating

The actual data carrier of a floppy diskette consists of a thin circular and pliable sheet of plastic that's been coated with a thin layer of magnetic material. The thickness of this layer is about 0.00008 inches (0.002 mm) for different types of disks. Depending on the nature of this coating and the disk format used, formatting places a series of tracks and sectors on the magnetic material, so data can actually be stored on the disk.



The inside of a 3.5-inch diskette

In 286 and more powerful PCs, only two different diskette formats are used:

- The 3.5-inch, 1.44 Meg high-density (HD) format
- The 5.25-inch, 1.2 Meg high-density (HD) format

Although both formats are widely used, the 3.5-inch diskettes are becoming more popular.

Identifying high density diskettes

The 3.5-inch diskette has a hard plastic case with a small metal sliding cover on one edge. This cover protects the magnetic media from dust and other damage. The metal cover slides to one side when you insert the diskette in a drive, exposing the magnetic media.

On the opposite side, the plastic diskette case has two square holes, one of which can be covered with a small plastic slider that's built into the case. This slider allows the disk to be write-protected. The disk drive receives write access to the disk only when the write-protect hole is covered. The status of the write-protect tab is checked before each write operation. The second hole is an identification hole found only on high density diskettes.

Size comparison for disk format

Fragile protection

The 5.25-inch diskette has a less stable construction than the 3.5-inch diskette. The actual data carrier is housed within a plastic jacket that provides only minimal protection. This diskette should be stored in a paper or Tyvac® sleeve to protect the oval access window. The diskette jacket bears a notch on its right side, which must be covered with an opaque sticker if the diskette must be write-protected.

The drive

Speed control

Disk drives consist of four basic components: The drive motor, two combined read/write heads, a stepper motor, and the controller circuitry. The drive motor, which runs only during disk access, rotates the magnetic media of the diskette. For 3.5-inch drives, this motor must maintain a constant speed of 300 revolutions per minute. A separate special control circuit ensures that this speed is maintained. For a 5.25-inch diskette, a speed of 360 RPM must be maintained.

5.25-inch diskettes have an index hole toward the inside of the carrier. During each revolution, a beam of light passes through this hole and energizes a photo diode. The duration between these pulses determines the number of RPM, then the controller regulates the motor speed accordingly.

A combined read/write head is provided for each side of the diskette. The read/write heads are in constant contact with the carrier surface once the diskette is placed in the drive.

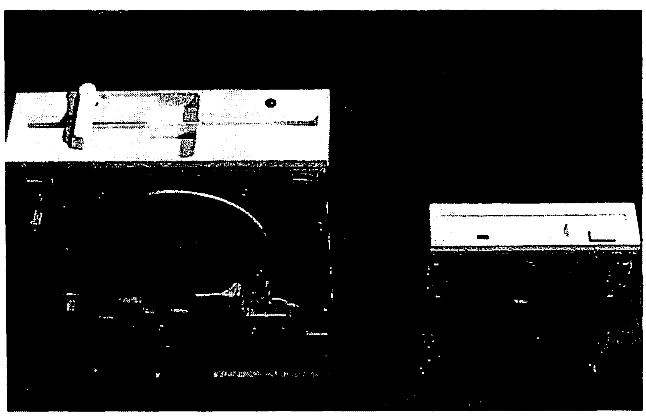
Obviously, the heads are subjected to a considerable amount of strain and wear. They are mounted on arms that move radially over the diskette's surface, so each track can be accessed.

These tracks are magnetically imprinted on the magnetic media, according to instructions from the operating system when the diskette is formatted.

The number of tracks on a diskette depend on the diskette format. For example, a 3.5-inch diskette will be divided into 40 or 80 tracks. In this case, each track will have a width of 0.01 inch (0.25 mm). The read/write heads are moved from track to track on demand by the stepper motor.

Two drives on one cable

The disk drive's control circuitry coordinates the actions of the drive motor, the heads and the stepper motor, as well as the communication with the disk controller. The drive's circuitry is connected to the disk controller, which is located on one of the PC's expansion cards through a 34-line ribbon cable. This cable allows up to two drives to be operated alternately by the controller.



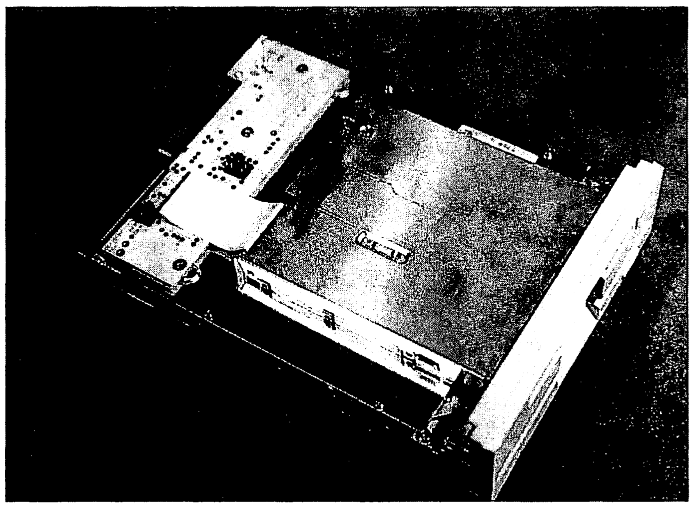
Size comparison for disk drives

The high density drives that are used in AT-class systems (286 and higher) are capable of formatting diskettes at 1.2 Meg (5.25-inch) and 1.44 Meg (3.5-inch) of data storage capacity.

They're capable of reading high density as well as low density formats. Also, by using special parameters, they're capable of formatting diskettes at low density capacities.

Two drives in one housing

One type of drive arrangement that's becoming more popular is the combination drive. This component consists of a very compact twin disk drive housed in a single case with only one cable connection. It contains one 3.5-inch high-density drive and one 5.25-inch high-density drive. The case of the combination drive actually fits in the mounting bay for a single 5.25-inch drive.



A combination drive

These drives don't limit the function or use of the storage medium in any way, and they seem to be a good way of creating more space in a cramped PC housing.

Recording method

The MFM (Modified Frequency Modulation) method is used in recording information on the magnetic coating of the diskette surface. The status of a data cell or data bit is determined by a magnetic flux change. If the center of such a data cell contains a flux change, then the cell's bit value is 1; if the flux change is absent, the cell carries the value 0.

Disk drives are usually reliable

Disk drives are usually reliable. Although disk drives are used frequently, they seem to work almost flawlessly under normal use. However, disk errors can still occur, owing to wear and tear or poor handling.

Hard drives

Most current PC systems must have a hard drive to operate properly. Applications no longer fit on a single diskette. Today programs whose data require 10-20 Meg of disk space are common. However, not only has the demand for disk space increased dramatically, but also the physical capacities of modern drives are very different from the standard capacities of years ago.

Physical characteristics of hard drives

Hard drives are always evolving

A modern hard drive is about six inches long, four inches wide, and less than an inch high. The complete drive weighs about two pounds and, in this form, stores up to 120 Meg of data. The first hard drive used in PCs had a storage capacity of 10 Meg, was four times as high, six inches wide, eight inches long, and weighed close to ten pounds. Improvements in the recording methods and a more compact and efficient control circuitry have led to these "external" changes.

The evolution of hard drive sizes

Hard drives are available in 3.5-inch and 5.25-inch formats. Hard drives with normal 3.5-inch dimensions (half-height drives) are available in capacities of up to 500 Meg. Larger capacity drives are made in 5.25-inch and full-height sizes. Hard drives that are used for home-based PCs are primarily 3.5-inch drives with a height of no more than 1.5 inches.

Unlike disk drives and other storage devices, hard disk drives are sealed units, from which the data carrier cannot be removed. Therefore, the commonly used term "hard drive" always refers to the drive unit as a whole.

The structure of a hard disk drive

Synthetic coating

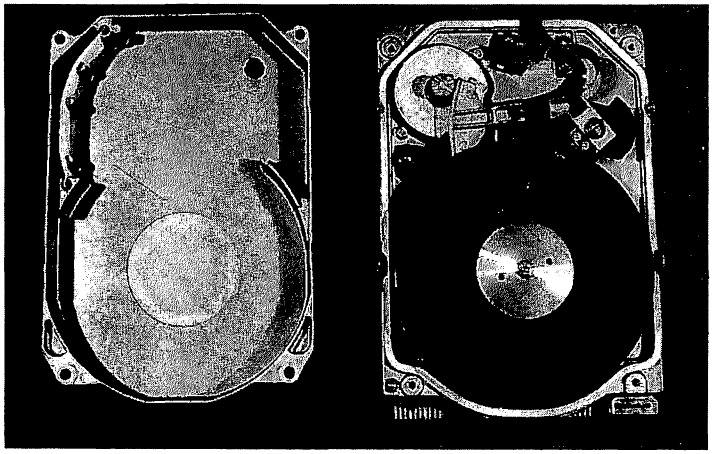
In all but the lowest-capacity hard drives, the hard drive consists of several disks that are arranged vertically and rotate around a common axis. These disks are made of aluminum and are covered with a synthetic coating that contains finely ground iron oxide, which allows the surface of the data carrier to be magnetized. Like floppy disk drives, hard drives consist of four component groups:

- The drive motor
- Read/write heads
- Stepper motor
- The control circuitry

Laptops are forced to conserve energy

The drive motor brings the disks to a rotational speed of 3600 RPM. Hard drives maintain this rotational speed until the power to the PC system is switched off. This occurs because it would take too long to bring the disks up to this speed before each hard drive operation.

The drive's control circuitry ensures that the rotational speed doesn't vary by more than half of one percent. Laptops and notebooks frequently use a Power Management Controller, which actually turns the hard drive motor off if the disk hasn't been accessed for a long time. This saves electricity and prolongs battery life. Before the next disk access can take place, the drive then has to be brought back up to the correct rotational speed.



The inside of a 5.25-inch hard disk drive

Average seek time

The combined read/write heads reach between the disk surfaces. So each disk can be accessed both on the top and the bottom. The heads are always moved together, although only one writes or reads at a given time.

They're mounted on arms similar to those found on floppy drives, and are moved radially from track to track by the stepper motor. This particular action (i.e., the movement of the drive's heads from the disk's edge to its center), is one of the primary differences that can be found between different types of hard drives.

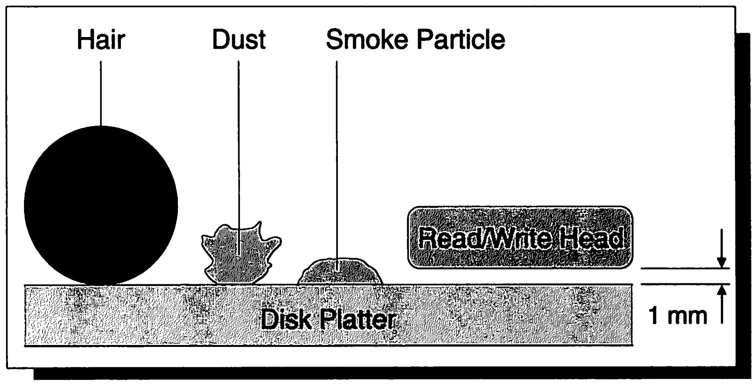
One of the technical specifications that can be used to compare different hard drives is average seek time. This figure specifies the average amount of time required for the read/write heads to reach a certain track on the hard drive. Common seek time values range from about 70 to 13 milliseconds.

Unlike the read/write heads of a floppy drive, hard drive heads don't touch the data carrier surface. At such high rotational speeds this would inevitably lead to both a damaged disk and a damaged head.

Instead, the heads float on a cushion of air caused by the high rotational speed. This is called the Bernoulli effect.

The distance between the disk surface and the head is so small that even a human hair is one hundred times thicker. Therefore,

the hard drive is enclosed within a hermetically sealed case. The presence of even a single grain of dust could result in a head crash. When this occurs the head actually touches the disk surface. Therefore, never try to open your hard drive's case.



Comparing the disk platter to particles of hair, dust, and smoke

Physical division of the hard drive

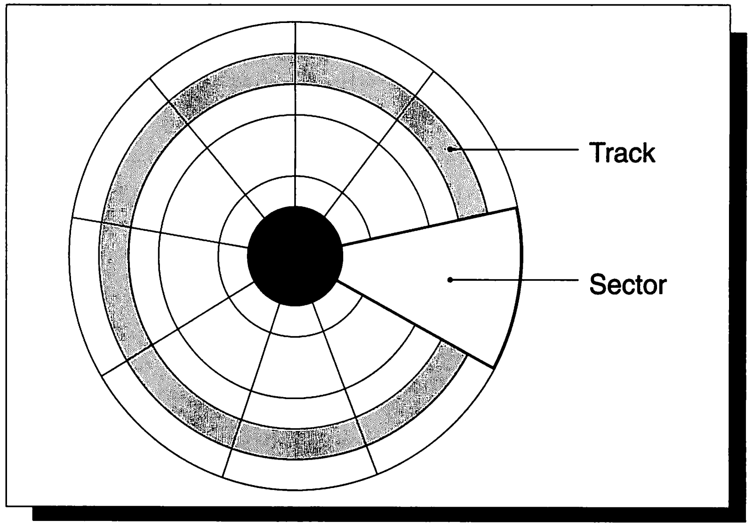
Dividing the disk surface

Before hard drives are imprinted with a logical division by the operating system, they are physically formatted. This process is also referred to as low-level formatting or hard formatting.

In this physical alignment of the magnetic surface coating, each of the drive's disks is imprinted with a type of division system.

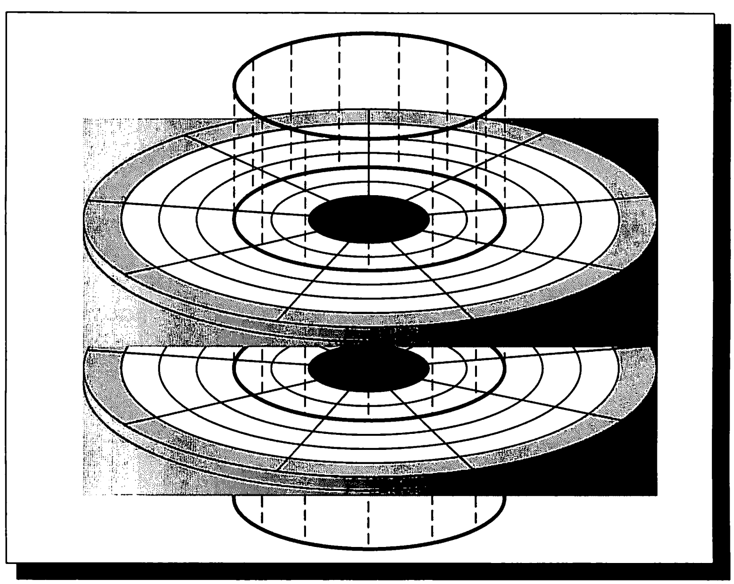
On hard drives, this division consists of tracks and sectors. Tracks are concentric circles on the disk's surface, similar to the rings of a tree trunk. These tracks are placed identically on each of the vertically stacked disks, so individual tracks line up vertically.

To visualize this, imagine a track as extending through each separate disk, in the shape of a hollow cylinder. The number of cylinders is simply the number of tracks on the hard drive.



Hard drive tracks and sectors

These tracks are further divided into sectors. This makes it possible to specify a particular area on the disk's surface precisely. For example, this type of address could be "cylinder 6, disk 2, bottom side, sector 8." This specifies an exact region on one of the disks in a hard drive.



Hard drive tracks and clusters

The number of tracks, or cylinders, are determined by the hard drive manufacturer; the number of disks and, consequently, the number of read/write heads are also determined by the drive's construction. However, the number of sectors that are created when the disk is physically formatted essentially depends on the recording method and, therefore, the data density that's used. This factor in turn depends on the quality of the magnetic surface coating of the hard drive.

Physical division and storage capacity

This physical structure, which varies depending on the type of hard drive, determines the disk's data storage capacity. The smallest physical increment on a hard drive is the sector. A sector is capable of storing exactly 512 bytes of data per track.

To calculate the total number of these 512 byte segments in a hard drive, you must consider three other values: The number of sectors, heads, and cylinders. As we mentioned, the number of heads and cylinders are determined by the manufacturer. As an example, we'll use the ST-251 hard disk drive by Seagate. This drive is equipped with 820 cylinders, 6 heads, and 17 sectors.

Calculating the storage capacity

Let's examine the surface of one of the coated disks more closely. After the physical divisioning, it's imprinted with 820 tracks. Since this hard drive uses the MFM method (see below), it's physically divided into 17 sectors. Therefore, each track contains 17 data segments of 512 bytes each. So the surface of this one disk is capable of storing 820 x 17 x 512 bytes, which results in a storage capacity of 7,137,280 bytes for that disk surface.

This particular hard drive model contains three rotating disks. So, it has six surfaces with this storage capacity, each of which is accessed by a separate read/write head. The total storage capacity of this hard disk drive is 7137280 bytes x 6, or exactly 42,823,680 bytes. Since one megabyte equals 1048576 bytes, this corresponds to a capacity of about 41 Meg.

So, the total data storage capacity of any hard drive can be calculated using the simple formula:

```
total = sectors x sector capacity x cylinders x heads
```

Most hard drives use a sector capacity of 512 bytes. However, since the number of sectors varies with the recording method used for a particular hard drive, it's possible that some hard drives may

have 26 or 34 sectors, even if the other parameters remain identical.

For example, the RLL method (see below) divides each cylinder into 26 sectors during physical formatting. If you replace the "sectors" value in the formula above with this number of sectors per cylinder, you'll receive a total storage capacity of 64 bytes.

This combination of parameters corresponds to the Seagate hard drive model ST-277R.

Gross or net?

Here we are referring to the drive's net capacity, which represents the amount of data that can be stored on the hard drive after it has been formatted under DOS.

Often the technical information provided with a hard drive lists the drive's gross capacity. This amount seems larger than the final net capacity because a certain amount of disk space is needed for disk management.

On larger hard drives with capacities of several 100 Meg, the difference between gross and net storage capacities can easily reach 30 Meg.

For example, a hard drive with a gross capacity of 2000 Meg (or two gigabytes) has a maximum net capacity of 1700 Meg (or 1.7 gigabytes). So you should be sure that you know a drive's net capacity instead of its gross capacity.

Logical hard drive division under MS-/PC-DOS

FDISK and FORMAT

Once the hard drive has been physically formatted as described above, the operating system MS-/PC-DOS Version 5.0 then places a logical division on the hard drive.

First, the DOS program FDISK is used to divide the hard drive into separate logical drives or partitions. Since Version 4.01, DOS has been able to manage larger hard drives within single partitions (i.e., as a single logical drive (C:)).

However, it's still possible and, in some cases, even better, to divide the hard drive into several logical drives (C:, D:, E:, etc.).

Once the drive has been partitioned into logical DOS drives, a logical structure is created within each of these partitions using the DOS FORMAT command.

Clusters and the File Allocation Table

DOS divides each logical drive into allocation units, which are also called clusters. These are the smallest units in which DOS is able to access the hard drive.

Each logical drive also contains a file allocation table (FAT). Each file that's stored on the hard drive is allocated at least one of these clusters.

A larger file, whose data blocks may be scattered throughout the disk, can be reassembled using the information stored in the FAT.

The FAT records to which file each cluster belongs. It also records whether further clusters belong to that file and where these clusters are located.

Cluster size varies

DOS manages its logical drives with a 16-bit file allocation table. This means that each FAT can contain a maximum of 2 to the 16th power (=65536) entries or clusters.

So the size of a cluster depends on the storage capacity of its logical drive. The smallest allocation unit under DOS covers 2048 bytes of storage space.

Starting at a hard drive size of 128 Meg, this cluster size becomes too small to allow the FAT to cover the entire drive.

Therefore, hard drives of 128 Meg and up use clusters that cover 4096 bytes. Hard drives of 256 Meg and up even use allocation units of 8192 (double the previous amount).

This pattern is followed until the maximum size of a logical DOS drive is reached; this size equals 2048 Meg or 2 gigabytes. DOS independently selects the appropriate cluster size during logical formatting.

Encoding method

Throughout the development of hard drive technology, the demand for increased storage capacity and optimized access times have increased significantly.

As a result, the system by which data is coded and recorded has also changed constantly.

By refining this system, it's possible to achieve a higher density of data on the surface of a hard drive. This increases the drive's overall capacity.

Although this increased density requires an extremely high degree of precision, it also requires the heads to move over smaller distances, which decreases access times.

The MFM (Modified Frequency Modulation) method

Basis of mass storage technology

The basis of mass storage technology is the MFM method, which we mentioned. This method has been the industry standard for disk drive systems for several years. Although MFM is still used on most floppy drives, most hard drives now use the more efficient RLL encoding.

In modified frequency modulation, electrical energy is transformed into a magnetic flux change within a data cell on the hard drive surface. This occurs through frequency modulation in the drive's read/write head.

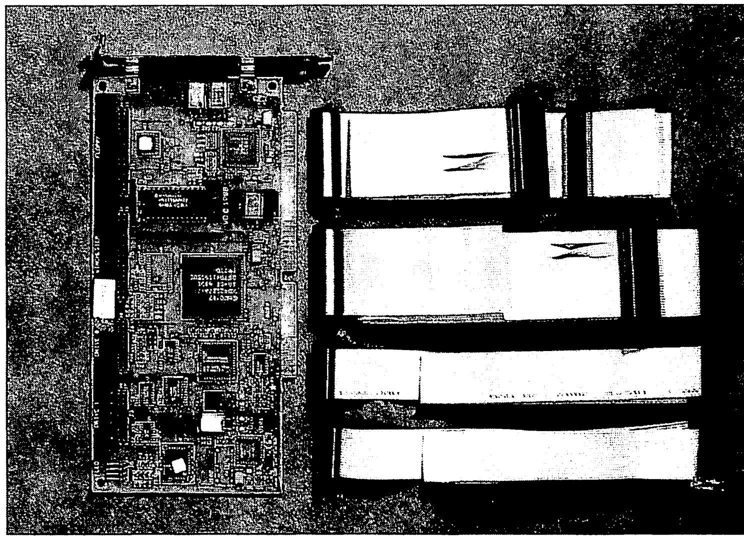
Data bits are defined by the presence or absence of such a flux change within each individual data cell. During read access, these magnetic flux changes are transformed back into electrical impulses through the read/write head.

Data is transmitted serially so each flux change is followed by one impulse, bit for bit, one after the other.

New controllers will present problems

This method has dominated the hard drive market, at least in "smaller" hard drives of up to approximately 100 Meg. The ST-506 hard drive controller is an excellent example of MFM hard drives.

This hard drive controller connects the hard drive with the PC's bus system. It consists of a rather complex expansion card that's connected to a maximum of two hard drives by a 34-conductor flat cable.



An MFM controller with controller and data cables

The data transmission to and from each hard drive takes place via a 20-conductor data cable. The MFM method requires the hard drive and controller to be a finely balanced, as well as a stable and completely synchronized operation sequence. So, installing a new controller can often lead to data transmission errors.

MFM hard drives are unable to provide information on their physical structure. Therefore, MFM drives must be "registered" with the operating system complete with all their parameters.

Therefore, the hard drives found in BIOS hard drive selection lists are almost exclusively MFM drives.

The RLL (Run Length Limited) method

Because of improvements in hard drive construction, such as an improved surface coating and a special controller that further stabilizes the drive motor's rotational speed, slightly different coding systems can be used.

IBM developed the RLL encoding method for their mainframe disk drives. In the late 1980s, disk drive manufacturers started using it to increase the storage capacity. Most hard drives now use a form of RLL encoding.

The successors of the MFM method are called the RLL 2,7 method and the RLL 1,7 method. These types of hard drives have a structure that's identical to MFM drives.

RLL 2,7 method

The RLL 2,7 method was initially the most popular because of the improved magnetic coating of the hard drives and the special controller allow 26 sectors per track to be installed during physical formatting. This results in a storage capacity ("density ratio") that's 50% larger than the storage capacity of MFM drives. However, the RLL 2,7 method did not work well with high capacity hard drives.

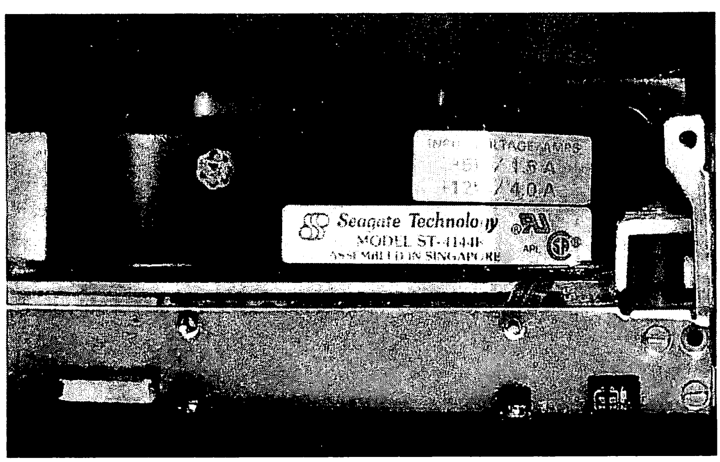
RLL 1,7 method

Therefore, most hard drives today use the RLL 1,7 method. These drives have a slightly poorer density ratio (1.27 of MFM) than the RLL 2,7 drives but are considered more reliable.

Identifying RLL drives

RLL hard drives are identified as such by the manufacturer. Although it's possible to format any MFM drive by using the RLL 2,7 format, this may cause data loss because the magnetic coating of MFM disks cannot handle the increased data density.

Seagate, for example, designates its RLL capable drives with an uppercase letter "R" after its model number (ST-277R).



RLL hard drive identification

Use the ST-506 interface format

RLL hard drives also use the ST-506 interface format. The connection between the controller and the hard drive is identical to the one used in MFM drives.

However, RLL controllers are often equipped with a special BIOS which must be informed of the hard drive being used. For more information about this procedure, refer to Section 2.

The ARLL (Advanced Run Length Limited) method

An additional increase in storage capacity, or density ratio, was achieved by further development of the RLL method. The RLL 3,9 or the ARLL method (Advanced Run Length Limited) permits an even higher data storage density.

Controllers using this coding system place 34 sectors on each track. This results in double the data density and, therefore, double the storage capacity of an MFM drive.

However, these hard drives were unreliable and more expensive since they required higher quality components and construction. The handful of companies manufacturing ARLL drives have virtually disappeared.

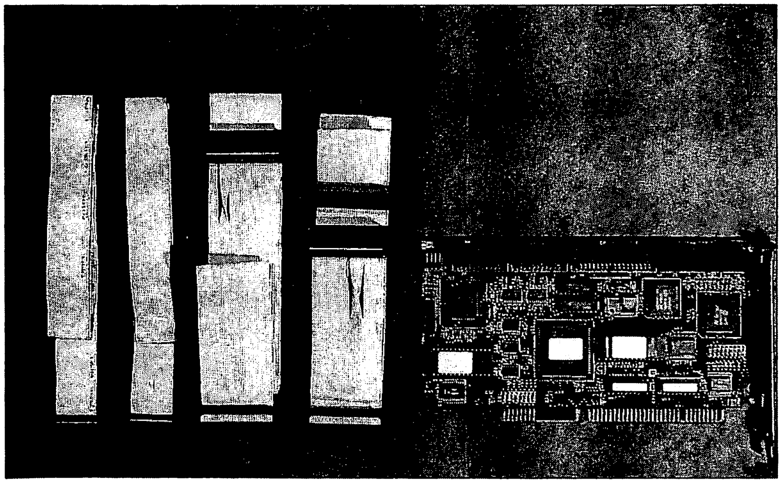
ESDI - the first interface for ARLL hard drives

The conventional ST-506 interface also had to be replaced, since it was no longer sufficient for the ARLL system. This replacement, from IBM, is called ESDI (Enhanced Small Device Interface).

Externally, an ESDI hard drive controller looks similar to the older ST-506 interface. It also uses a 34-conductor controller cable for a maximum of two hard drives and a 20-conductor data cable for each of those drives. It can replace the ST-506 without affecting software in the system.

The "intelligence" of ESDI hard drives is located in the drive's circuitry. This actually makes these hard drives superior to other systems.

Unlike the ST-506 system, in which the controller card encodes and decodes the data, the ESDI hard drive performs this task itself. Since this drastically reduces communication distances, transmission time is also reduced.



An ESDI combination controller

The development of ESDI hard drives and special ESDI controllers has permitted a data density of up to 53 sectors per track. Compared to an otherwise identical MFM drive, this triples storage capacity.

Until recently most high-end systems used ESDI controllers and drives. However, lately many companies are changing to SCSI controllers and drives.

TIP

Because SCSI interfaces have more features and greater expandability, you should not install an ESDI drive in your system unless you're upgrading a system which already has an ESDI controller.

SCSI - An intelligent interface standard

The SCSI hard drive system offers a completely different approach than the systems described. The SCSI (Small Computer System Interface) is the only controller that allows more than two consecutive hard drives to be driven. This is possible because the SCSI system isn't only a hard drive system.

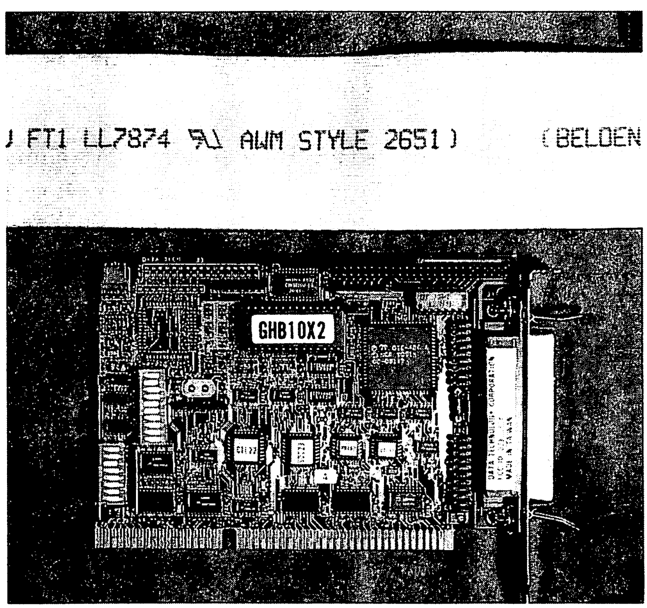
SCSI primarily consists of a standardized interface, through which intelligent subsystems can be connected to the PC's bus

system. Connecting one of these intelligent subsystems to a computer requires only a simple host adapter.

These host adapters are used with various types of SCSI devices (tape streamers, printers, scanners, etc.). The "brains" of the SCSI system are always found on the actual device or peripheral.

However, an SCSI controller is more than just a host adapter. It's capable of managing eight SCSI devices, including itself, in one PC system.

It doesn't matter whether these eight devices are tape streamers, hard drives, scanners, printers, or simply several separate hard drives. So an SCSI controller shouldn't be confused with a hard drive controller.



ASCSI controller with a 50-conductor cable

On an SCSI drive, the hard drive controller is always built into the hard drive's on-board control circuitry. Unlike the hard drive systems we discussed earlier, hard drives with SCSI interfaces transmit data in parallel, so eight data bits are transferred simultaneously.

IDE interface - an affordable solution

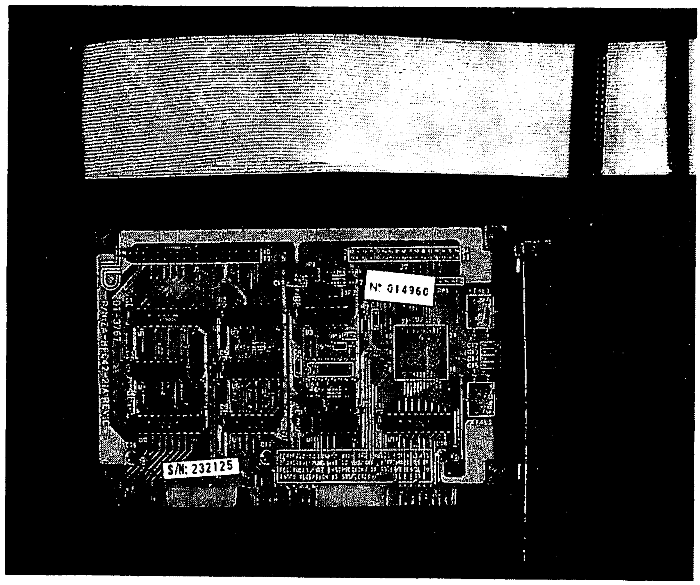
Conner Peripherals, a hard drive manufacturer that was trying to develop a small, fast, and high-capacity drive for portable computers, developed the IDE (Integrated Drive Electronics) interface. This interface has emerged as the new standard of PC hard drive systems.

More commonly known as AT bus hard drives, IDE interface drives are a standard in today's high-speed 386 and 486 systems. Not only do these drives offer many advantages but they are very low cost to manufacturer.

The AT bus interface consists of a 40-conductor cable. This cable passes data from the hard drive controller over a simple type of host adapter directly to the 16-bit bus. Even in the case of AT bus boards, the actual hard drive controller is located within the control circuitry of the drive.

IDE hard drives use a coding system that's similar to the RLL and ARLL method. This means that they also use high data storage densities. However, to the PC system, IDE drives will usually emulate a standard MFM or RLL hard drive.

To increase the capacity of an IDE drive, more data is packed onto the small disk surface.



The AT bus controller with a 40-conductor cable

To see how this is done, visualize how a hard drive is divided into individual sectors.

Let's use an example. Imagine a pie that's decorated with concentric rings of cherries. If this pie is then divided into 17 equal slices, the result would represent the typical structure of an MFM drive with 17 sectors. On the pie you'll be able to see that the outer cherry rings contain noticeably more cherries than the inner ones. However, hard drives aren't structured this way. Think of the calculation of net storage for a hard drive. Each sector always had a capacity of 512 bytes per track, regardless of whether that sector was located on an inner or outer track. So, Conner Peripherals developed hard drives that are able to place more sectors on the disk's outer tracks. This special division is managed by a complex integrated control circuitry, which allows the system to address the drive like any "normal" hard drive.

The translation parameters are stored in the CMOS of the system BIOS, and the integrated on-drive controller then translates disk

operations into the logical division of the hard drive. So the hard drive operates in translation mode.

Low-level formatting isn't allowed

This is also why AT bus hard drives needn't be physically formatted when they're used for the first time. A low-level format would destroy the manufacturer's logical structure. This would make the hard drive only partially usable, if at all. IDE hard drives simply need to be imprinted with a DOS structure, which consists of the logical drives and allocation units described above.

Under normal circumstances, it's possible to operate two IDE hard drives with one interface. However, you must ensure that the two integrated controllers don't compete with one another for the leading position within the system. To do this, one of the drives is declared the master drive and the second is declared the slave drive. This creates a clear hierarchy for disk operations.

Any bad tracks?

Another special characteristic of AT bus hard drives is their integrated error correction. With the other hard drive types that we've discussed, unusable spots on the disk's surface are marked as "bad tracks" during physical formatting. This ensures that this track won't be used for data storage in subsequent disk operations.

However, AT bus hard drives set aside one reserve sector for each data track. If errors are discovered on a particular track, this spot is automatically replaced by the reserve sector. Since the track remains unchanged externally, an AT bus hard drive always appears error-free.

Data transfer rate of different hard drive types

If you compare the performances of various hard drive types, you'll discover some very drastic differences. However, these differences can be caused by unrealistic conditions or criteria.

Average seek time

The average seek time and the data transfer rate are two key specifications that are frequently used in such comparisons. The average seek time is measured in milliseconds (ms) and the data transfer rate is specified in kilobytes per second (K/sec). The average seek time specifies the average amount of time required for the read/write head assembly to move from any given track to another.

Since this value isn't influenced by any other factors, it's a reliable way to compare drive types. However, its significance is somewhat limited. For example, a drive with a low access time of under 20 ms doesn't automatically perform better than a 25 ms drive.

Data transfer rate

The data transfer rate is the crucial factor because this is the value that determines how much data the drive can actually read or write in a given amount of time. However, first this value is determined using different criteria. Then the data can be arranged in so many different ways on a disk that the resulting transfer rate can vary considerably.

Even the size of hard drive partitions can affect the drive's performance. Also, the points at which the performance measurements are made will influence the final value. Is the data transmission timed between the hard drive and main memory or between the hard drive and its controller? Unfortunately, there isn't a standard way to conduct these tests.

Unreliable specifications?

Therefore, you shouldn't rely on these tests because their results may not always be accurate. The installation of cache programs, or the presence of a disk cache, (see below) will also distort the test results.

Calculating the transfer rate

For this example, we'll use an MFM hard drive with 512 byte sectors and 17 sectors per track. Each track contains 512 x 17, or 8704 bytes of data. The most the read/write head can read during each disk revolution is one entire track. So, at a speed of 3600 RPM, the head could read 60 data tracks in one second.

Assuming that no time is lost in passing the data from the head, the drive is capable of reaching a transfer rate of 8704 x 60, or 52240 bytes per second. About 12% of this data volume must be subtracted for file management data so the final data transfer rate would be about 450K/sec.

However, "transfer rate" isn't really the correct term for this value, since this figure indicates only how fast the drive can physically read the data. The time that's required for the data to reach RAM, for example, isn't known. Therefore, an MFM drive is

physically incapable of exceeding 450K/sec. This is the value that must be worked toward in optimizing the drive's practical operating conditions and influences.

Since RLL hard drives use a higher data storage density, a single RLL data track contains 13,312 bytes of information. So the read/write head can transfer more data at the same rotational disk speed. After subtracting file management data, this data density results in a maximum value of about 700K/sec, under optimum conditions. This proves that the coding system is an important factor in the final data transfer rate.

Clock frequency

Under ARLL and an ESDI interface, data transfer rates of approximately 1.5 Meg can be reached, under optimal conditions. One of these conditions is that the PC system (remember that the hard drive controller is hooked up to the PC's bus) is capable of receiving and processing data at this speed.

For example, a fast RLL hard drive won't be able to use its full potential in a 286 system running at 10 MHz. Here the PC system would slow down the drive. The conditions are optimal only when a fast data source has a receiving address that is always ready to receive data.

SCSI hard drive systems are also capable of reaching data transfer speeds of over one Meg per second. However, you must use a good SCSI controller and not any inexpensive host adapter, to achieve these results. Even then, you must load drivers that have been specially designed for that controller. As long as you're operating a SCSI hard drive with only a simple SCSI host adapter, you'll hardly be able to reach data transfer rates that exceed those of RLL drives.

Increased performance through hardware caches

By using the described recording method, AT bus hard drives can reach data transfer rates of 600 to 800K/sec. However, most AT bus hard drives are equipped with a special disk caching system that positively distorts the transfer rate. Similar to the process used in RAM caching, data read from the hard drive and passed to main memory is also recorded in a buffer. So the next disk operation can be executed with information from the buffer. This makes a physical disk access unnecessary.

This cache system is extremely useful with programs that use frequently-repeated commands or command structures. The response time of the cache is understandably much shorter than that of the actual hard drive.

Fewer physical disk operations also save wear and tear on the drive's mechanical components. The disk cache can be located either on a special cache controller (primarily on SCSI and ESDI controllers) or directly on the hard drive circuitry. The latter approach is being used more often with AT bus hard drives.

Increasing the data transfer rate

As we discussed, each hard drive type has a maximum data transfer rate that's physically determined by its coding system and the interface that's used. Once you know this, you can optimize the hard drive's organization and access method to come as close to this maximum transfer rate as possible.

The terms "data throughput" and "data transfer rate" always refer to the amount of data that can be moved from RAM to the hard drive, or vice versa, within one second.

Interleave ratio

When a hard drive is physically formatted, each of its tracks is divided into a specific number of sectors. Before this division can occur, the drive's interleave ratio or setting must be determined.

This setting determines the logical sequence in which the sectors of a track are accessed during the disk rotation. The controller uses these sectors as a read/write address.

To clearly understand how difficult this task is, imagine that the disk is a dart board. The outer track is marked and divided into 17 equally large sectors. The disk begins rotating at a constant speed. Your task is to throw darts at the disk until all 17 sectors are full of darts.

Since you're an excellent shot, you always hit the top sector. An assistant hands you the darts at a constant speed. Your task is complete when the entire track (all 17 sectors) is full of darts.

If your assistant can hand you the darts at a proper speed, you'll complete the task after one revolution of the dart board. However,

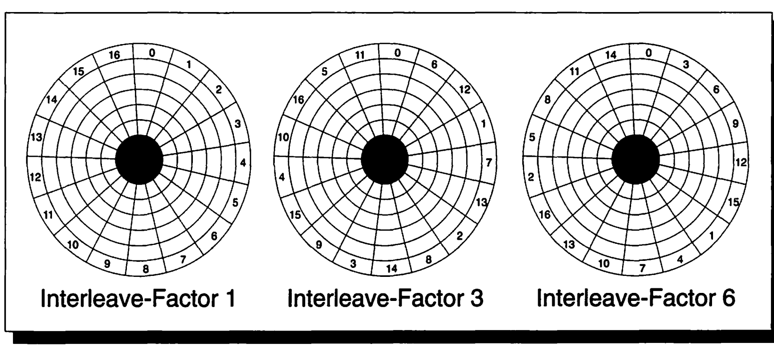
if your assistant is a little slower, you'll need more than one revolution to fill the dart board with darts.

The same thing happens even if your assistant is fast enough, but the darts are handed to him or her too slowly.

The dart board with its sectors represents an MFM hard drive, you represent the read/write head, and the darts represent data. Your assistant is the hard drive controller and his or her dart supplier is the PC's data bus.

The number of sectors that move underneath the head, before it receives the next instruction from the controller, corresponds to the number of disk revolutions it requires to write on or read a complete track with all of its sectors.

A fast controller with a fast data bus can pass data so quickly that the sectors can be read continuously in their physical sequence. So after one revolution of the hard drive, the head can read the entire track and the data are already on their way to the processor.



Interleave ratios of 1, 3, and 6 for tracks with 17 sectors

The slowest component sets the pace

However, if one of the components in this chain is too slow for this pace, the logical sequence of sectors must be organized differently than the physical sequence. Therefore, this sequence will be inherently different from the physical sequence in which the sectors are actually found on the disk.

This is exactly what the interleave setting determines. For example, if you specify an interleave setting of 3, the read/write

head will access only every third sector. So, three complete revolutions will be needed to access that entire track.

Often less is more

An incorrect interleave setting can produce drastic consequences for the data throughput between the hard drive and the PC's memory.

For example, an experiment with different interleave factors showed that a fairly slow MFM hard drive in a 25 MHz 386 system with an interleave ratio of 3 achieved a transfer rate of 182K/sec. Changing the interleave setting to 1 increased the transfer rate by 40%, which raised the rate to 297K/sec.

Although this still isn't the best data transfer rate, the increase obtained by correcting the interleave is impressive. In a test with a 10 MHz 286 system, the same hard drive with the same controller operated at a disappointing throughput of 33K/sec.

In this case, returning the interleave setting to 3 was preferable. This brought the transfer rate up to 182K/sec, which resulted in more than a five-fold increase.

The optimal interleave setting for a PC system can be determined only through experimentation. Unfortunately special software is needed to change the interleave factor without losing data.

Otherwise the hard drive will have to be low-level formatted with different interleave settings. Then a test program must be used to determine the transfer rate for each interleave.

Defragmenting files

Cleaning up your drive

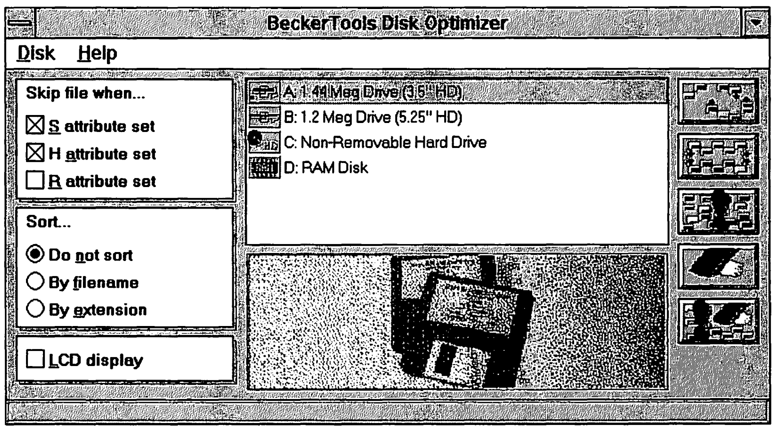
In discussing the logical divisioning of the hard drive, we determined that DOS arranges the hard drive with allocation units or clusters. When software is installed on the drive, files are distributed sequentially over these clusters.

Then these files are often lengthened or shortened and occasionally entire regions of the hard drive are deleted. So subsequent file operations can cause larger files to be scattered over the hard drive in numerous fragments.

This condition, which is a natural result of hard drive use, is known as file fragmentation. As a result of fragmentation, the read/write head sometimes must access many different tracks to

access the scattered portions of a single file. Since this is a time-consuming process, the data transfer rate decreases.

To avoid the problems caused by fragmentation, you should defragment your hard drive regularly. Several programs, such as BeckerTools Disk Optimizer from Abacus, provide an effective and simple way to do this.



BeckerTools Disk Optimizer

Increasing the bus frequency

Another way to increase hard drive performance applies to motherboards with NEAT chip sets or motherboards with 386DX or higher processors. The bus system usually operates at the original AT frequency of 8 MHz.

With these particular motherboards, it's possible to change the bus system frequency in the CMOS setup. However this change may cause problems with some PC components, especially expansion cards.

So, you should try to raise the bus frequency only in smaller increments. In Chapter 8 we'll describe these steps.

Swapping your controller

Improved interleave

If you follow these steps but the data transfer rate of your system still isn't increased enough, you may have to install different hardware components. The correct interleave setting is extremely important if you have an MFM or RLL hard drive.

In this case, you should ensure that your hard drive controller is capable of operating at the ideal interleave ratio, particularly if this ratio is 1:1. Older MFM and RLL controllers are usually designed for interleave ratios of only 1:3 or 1:2.

However, in this case, installing a new controller is useful only if you're absolutely sure that the optimal interleave for your system is 1:1.

If you own a fast hard drive system (ESDI, SCSI), you may also want to consider installing a hard drive controller with up to 2 Meg of cache. This can increase hard drive performance significantly.

Swapping hard drive systems

If you've tried to increase your hard drive's performance with all the non-hardware options but you're still not satisfied with the results, you may want to purchase a new drive.

One option is to swap your current hard drive for a drive with a lower average seek time. Although this will improve the system's performance slightly, a significant improvement can be achieved only if the new drive is at least 10 ms faster.

You can achieve the largest increase in performance by installing an entirely new hard drive system.

Switching software

You should also remember that several other factors affect the data transfer rate between your hard drive and your PC's memory. Often these are indications that your entire system lacks the necessary performance.

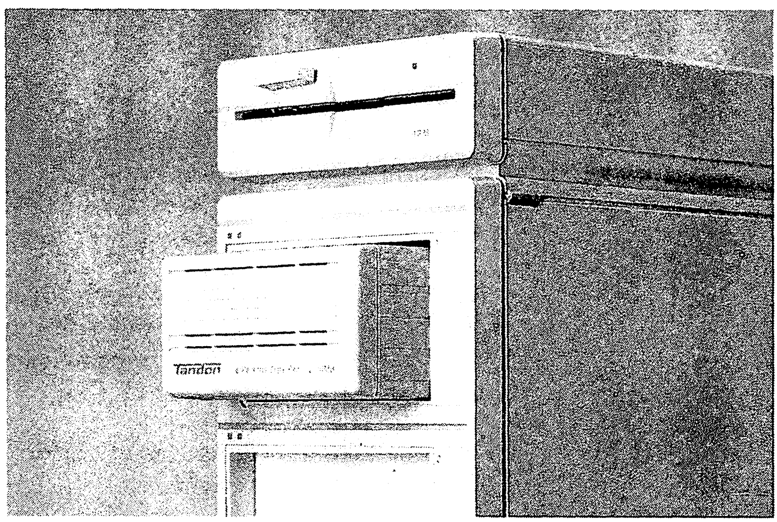
This problem can usually be solved only through radical upgrades, such as exchanging your motherboard while also installing a new hard drive system and additional RAM. This is especially true if you're switching from a text-oriented user interface, perhaps on a 286 PC with 40 Meg of disk space and 1 Meg of RAM, to a graphical user interface, such as Windows 3.1.

In this case, the installation of a more powerful hard drive causes a slight improvement in performance. However, without an improved overall system, you'll never be able to use the capabilities of a more powerful drive.

Removable storage systems

Various types of removable storage systems are becoming more popular. These systems are used for backing up data.

A simple version of a removable storage system is the data pac. The entire hard drive is stored in a separate case. The back of the case has plug connections so you can plug into the controller, the cables, and the computer power supply when you insert the pac in the PC. AT bus hard drives are generally used for data pacs.



A Tandon Data Pac

The data pac can easily be removed from its slot on the PC and, if necessary, swapped for another one. This is a very practical system, as long as the same type of data pac is always used.

However, since the entire hard drive is removed from the PC with the data pac, this system can't really be considered a removable storage system, because the actual concept is to provide a portable data carrier instead of a portable drive.

So the purpose of removable storage systems is to combine the flexibility and portability of a floppy disk drive with the memory capacity and access time of a hard drive. This requires a hardware-based separation of drive circuitry and mechanics and the actual data carrier.

It also requires that the data carrier be enclosed in a hermetically sealed protective housing to protect the system from dust and other particles.

The Bernoulli box

Aviation technology

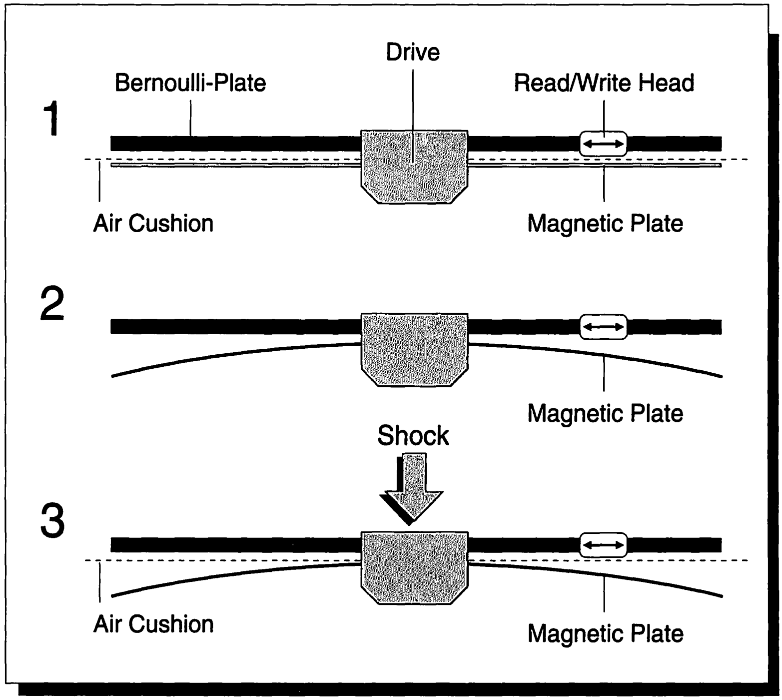
The Bernoulli box is a popular backup device. This system uses a principle that was discovered in the 18th century by the Swiss physicist Jean-Baptiste Bernoulli. His discoveries, which have been applied to aviation technology, form the basis for the function of the Bernoulli box.

Bernoulli found that the pressure on a surface diminishes in proportion to how quickly gases or liquids flow over the surface. The special section of an airplane wing causes the air on the upper part of the wing to stream past more quickly than the air on the lower part of the wing.

Consequently, the pressure on the upper surface of the wing becomes less than the pressure on the lower side as the horizontal speed increases (liftoff or thrust). The resulting difference in pressure allows the plane to rise.

In the Bernoulli box, a flexible disk, similar to a floppy diskette, is mounted below a flat stationary surface. The disk rotates around a spindle in the middle of the disk. At the same time, the air above the disk accelerates. The difference in pressure lifts the edge of the disk, which "sags" when at rest.

At a rotational speed of 2000 RPM, the disk attains a shape that is completely flat and even. It is separated from the surface of the read/write head by a stable layer of air. So physical contact between the disk surface and the head is impossible under normal operating conditions, like in normal hard drive systems.



Bernoulli box: (1) active (2) inactive (3) during a shock

In all other respects, a Bernoulli box operates like any other hard drive. The relatively high rotation speed permits a high data density, and the access times that can be achieved with Bernoulli drives are comparable to those of slower hard disk drives. Like floppy disks, Bernoulli disks can be swapped easily.

They are available in capacities ranging from 20 to 40 Meg, and look like audio CDs. Although Bernoulli drive units are also available in double drive formats, they are much more expensive than comparable AT hard drives, even if you have many Bernoulli disks.

The drive is controlled by a simple host adapter. If there are many other expansion cards, this adapter frequently encounters addressing conflicts. However, the adapter's address can be selected manually.

Modern removable storage systems

Different manufacturers are offering increasingly more powerful removable storage systems. Storage capacities have already reached one gigabyte, and average seek times range from 12 to 60 milliseconds.

So it's possible to replace your entire hard drive mass storage system with a removable storage system, without a loss in performance. Since some removable storage systems are based on the ST-506 interface, they can be driven with a normal MFM combination controller.

However, these particular systems don't have the best access times and storage capacities. SCSI devices, which can be connected to either a separate small host adapter or a full SCSI controller, have a much better performance level. These drives usually require special software drivers.

Surface material

Modern removable storage systems use one or two different types of magnetic surface materials; one is laminated and the other is coated. Laminated carriers are synthetic disks that are covered with a type of paste containing iron oxide particles.

This layer is relatively thick, measuring between 0.5 and 0.8 micrometers. Coated carriers are metal disks onto which a cobalt-alloy is sprayed. This is a much thinner layer, measuring between 50 and 100 nanometers.

Removable SCSI storage systems are ideal for backing up data, since they can easily be installed alongside numerous other hard drive systems. Such a setup permits extremely fast data transfer between a hard drive and a removable disk. This is probably the quickest way of backing up large amounts of data.

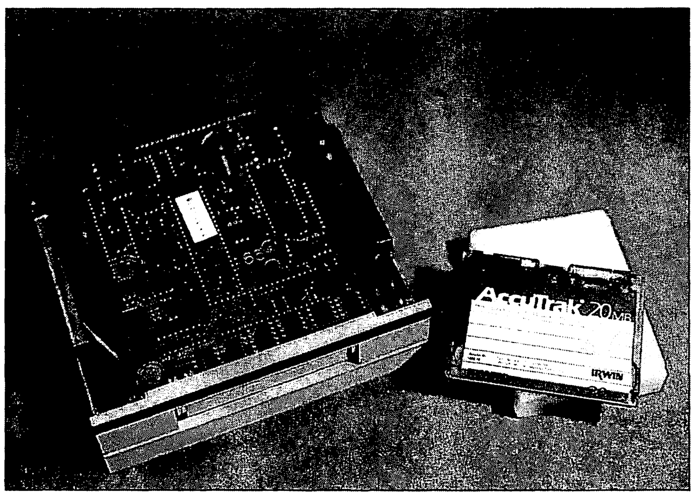
Tape drives

It's very difficult to back up a 100 Meg or more hard drive on floppy diskettes. However, tape drives provide an affordable alternative. These devices are ideal data backup systems because of their unlimited storage capacity and the high level of data security ensured by their thorough error correction methods.

Streamers

These tape drives are also called streamers. You can install streamers either internally or attach them externally to the case. Tape drives known as floppy streamers can be driven by the floppy disk controller in your PC.

They are available in storage capacities of up to 250 Meg, but rarely exceed data transfer rates of over 100K/sec. The floppy disk controller simply isn't capable of transmitting data at a higher rate. However, floppy streamers are affordable.



A floppy streamer with cartridge

High performance with SCSI

Other streamer drives require a special adapter; usually a SCSI host adapter is needed. These types of streamer drives easily reach capacities of 500 Meg. External streamers are almost always equipped with a SCSI interface. This type of streamer isn't registered with the system and it isn't assigned a logical drive letter.

To access the streamer, the data backup software simply locates the streamer at a predetermined port address and accesses it at this location. The streamer drive is useless without this special software. The data transfer rate of streamers using SCSI interfaces mainly depends on the particular SCSI controller. Usually you'll also be able to install special software drivers that can increase

the transfer rate even further, which permits data throughput of approximately 11 Meg per minute.

The data carriers used in streamer drives consist of specially designed data cartridges, similar to audio tapes. Through special software-based compression techniques sometimes it's possible to store information on these streamers at double capacity. Like diskettes, these cartridges also must be formatted before they can be used to store information. Since this process is time-consuming, you may want to purchase pre-formatted cartridges. Data backup cassettes are also available in different sizes, similar to floppy diskettes. The most common sizes are the 3.5-inch and the 5.25-inch formats.

Complete data backup with minimal effort

The most important advantage of a tape drive is its ability to back up an entire large hard drive in one operation. However, the data backup software is usually also equipped with various backup options. It's possible, for example, to back up only selected files, or you may want to backup files depending on their time and date labels. By using a tape drive along with a good data backup program, you can easily perform hard drive backups.

Compact disks

You've probably seen and heard audio compact disks. CDs, which contain up to 72 minutes of high-fidelity stereo sound, have almost replaced analog LPs. Now CDs are being used in the computer world as digital mass storage devices.

Enormous data capacities

Although CDs have enormous storage capacities, they are still operating at fairly low access rates. Compared to the data transfer rates of today's computer devices, a CD drive's performance is similar to that of older hard drives. However, this small and useful storage medium has several advantages. The most significant advantage is that it's less expensive to produce a 600 Meg CD than to produce the data carrier used in a comparable hard drive. Compact disks operate without wear, they offer extremely high data reliability, and most importantly, they can easily be swapped.

So the potential storage capacity of a single CD drive is limited only by how many individual CDs you're willing to purchase. It's possible to access entire software libraries by simply inserting different CDs.

While all the data storage devices we've discussed up to now have used electro-magnetic read and write techniques, CDs rely entirely on optical technology. A laser beam reads the information stored on the CD. The disks are composed of a reflective layer of aluminum applied to the synthetic base, which is then covered with a layer of transparent polycarbonate. A final protective coating of lacquer is applied to protect the disk from dust, dirt, and scratches.

Pits and bits

Like phonograph records, CDs are imprinted with only one spiral data track. However, unlike a record groove, this track is read from the center of the disk outward. The track is only 6 micrometers wide, and the space between the spiral measures only 1 micrometer. Data is stored on this track through vertical depressions in the aluminum layer.

The transition from the surface level (land) of the aluminum layer to a depression (pit), or vice versa, is what actually carries the logical information encoded on the disk. While other mass storage devices use the presence or absence of a magnetic flux change to designate a data bit, optical storage media indicate this through the presence or absence of a level change in the surface of the media. A photo diode timing circuit analyzes the reflection of the laser beam to determine whether the step to or from a pit has just been passed.

The rotation speed of the disk depends on the position of the laser head. When the inside of the disk is being scanned, it rotates more slowly than when the head is at its perimeter. So the variable rotational rate of 200 to 530 rpm permits the laser beam to scan the disk's surface at a constant linear velocity.

CD-ROM drives

One disadvantage of physically imprinting the information on the disk's surface is that the data is permanent. The pits used in encoding the data are actually burned into the disk's aluminum coating, which makes it impossible to write over information stored on optical data carriers. This also means that the CD-ROM drive isn't equipped with the usual read/write head. Instead, it has a laser gun that directs a laser beam at a track on the CD-ROM and a light-sensitive element that registers the reflections of the laser beam and transforms them into electrical impulses. These pulses, or the information stored there, are ultimately sent to the PC's bus system and the CPU.

Error correction

The circuitry of a CD drive also has another difficult task. It ensures that errors in the data flow are recognized and corrected. A complex process is used to read and evaluate the control, correction, and synchronization bits that are stored on a CD in addition to the actual data.

This lowers the system's error rate to a level that virtually eliminates data errors.

Drives designed to read optical data storage media are also referred to as CD ROM drives. Since the information on CDs can only be read, the term "Read Only Memory" was borrowed from the PC's system memory to describe this method of data storage.

These ROM storage devices are particularly well-suited for data bases that don't need to be updated or modified. This is an ideal way of making larger software collections available to the customer in a simple and compact way.

CD drives are usually connected to the PC's bus system by a SCSI interface and every CD ROM drive is shipped with at least a basic host adapter.

Like any other SCSI device, the drive doesn't have to be registered with the system. However, special driver software that should be included with the drive system must be installed.

WORM

A special development in CD drive technology is the WORM system. WORM is an abbreviation for "Write Once Read Many". This type of CD drive allows information to be stored on the CD by the user.

However, it's possible to write information to these disks only once. This data is then permanently stored on the disk and cannot be deleted or overwritten. It's possible to read the data stored on the disk as often as necessary.

A WORM CD is constructed slightly differently than conventional CDs, although the information stored on such a disk can be read by any normal CD ROM drive. A pigment layer is applied between the base layer and the reflective aluminum coating.

When data is written to the disk, a laser beam energizes this layer of color, vaporizing a small portion of the layer. This creates a vapor bubble that expands into the base layer, forming a pit.

Since the permanence and irreversibility of the information stored in this manner is inherent in the physical nature of the data carrier, it is often used for document and graphic file archiving. For the same reasons, CDs are suitable for storing legal and judicial information.

Kodak Photo CD

The Kodak Photo CD allows you to have films "developed" onto a CD rather than on photographic paper. These images can be displayed on a television screen or transferred to videotape. The Photo CD also plays audio CDs through headphones or your stereo system.

The Photo CD may not replace the old "family album," but it may lead to other creative methods of saving memories in pictures.

Multi-Speed CD-ROM Drives

You don't have to buy a Photo CD to take advantage of viewing CD photographic images. The latest wave of CD-ROM drives are triple and even quadruple speed. This means that in addition to the normal speed used for CD-ROM and audio CD playback, the higher speed and XA (eXtended Architecture) Standard make these multi-speed drives Photo CD compatible. With a multi-speed drive and the proper software, you can view Photo CDs.

Magneto-Optical Storage Media

PC storage devices must be able to be written on repeatedly. Also, they must have an exchangeable data carrier, high storage capacity, and fast data access. Data storage techniques that use data carriers with magnetic surface coatings aren't suitable for storing extremely large amounts of data on a minimal storage surface.

The maximum permissible data density is predetermined by the method used to read the information stored on the medium. The use of a laser beam in scanning the data carrier allows for an

exceptionally high data density and therefore also for large amounts of data to be stored on a minimal surface area.

However, this storage technique is based on permanent physical imprints in the storage medium.

The combination of these procedures has resulted in a system that uses a magnetic data write procedure and an optical read method. This means that instead of a combined read/write head, two separate heads perform write and read access.

Magneto-optical drives are a successful combination of both techniques.

MO disks

Similar structure to WORM CDs

The structure of MO disks (MODs) is similar to that of WORM CDs. Between the base layer of polycarbonate and the reflective coating, a layer of rare-earth alloy is applied. This material reacts to optical as well as magnetic influences.

The "write head" of an MO drive consists of a powerful laser that heats tiny portions of the disk's surface to 160 degrees Celsius. This places the magnetic elements of the rare-earth alloy layer in an unstable state.

While these particles cool to lower temperatures, a magnetic field is used to align them a certain way, creating a magnetic spot. So, writing on a MOD creates or deletes such magnetic spots.

This information is read by a weaker laser. A special technique is used to determine the alignment of the magnetic spot through the beam's reflection and its polarization angle.

A photo diode is used with a polarization filter to transform the optical signals into electrical impulses which are interpreted and processed by a SCSI interface before being sent to the bus system.

The level of precision required by this read/write technique necessitates the presence of an exact data track, which is imprinted on the MOD by the manufacturer.

Storage medium of the future?

The MO drives available today transfer data through their SCSI interfaces at rates of about 700 Kb/s, and at average seek times around 30 ms. These are acceptable performance values. However, these values will probably improve as the technology is refined.

Then these drives will be able to compete with the performance of faster hard drive systems. The availability of this technology at affordable prices would solve the problem of mass data storage, especially with ever increasing amounts of information, by providing a powerful and fully exchangeable medium.

However, currently these drives and the disks they require are still so expensive that it will probably be awhile before they are widely used.

Flash RAM

An entirely different type of storage medium is currently being developed. This device consists of RAM chips that can retain information permanently without using electricity to sustain their information.

So, unlike conventional RAM chips, these chips don't have to be refreshed. These chips permit much shorter access times than normal mass storage devices. Generally access times of 200 nanoseconds are possible.

Special memory cards can already be purchased. This technology is currently being applied to portable computers. However, this medium won't be able to replace conventional mass storage devices for many years. A single Meg of flash RAM still costs as much as an entire 120 Meg AT bus hard drive.

2.3 Input and Output

This function group of your PC differs from the components we've already discussed. The devices belonging to this group are usually located outside the PC's case. So, although this group is technically part of the computer's periphery, most of these devices are essential to the operation of a PC system.

Communication between user and PC

Most of the devices or component groups described in this section allow the computer and its user to communicate. They permit the user to enter data into the PC, to direct the processing of this information, and also to receive the processed or recorded data.

Therefore, these devices are designed to translate human forms of communication into information that can be processed by the computer, and vice versa. This process is possible only within a specific framework or structure.

Although there are exceptions, verbal speech generally cannot be used to send data to the computer. The most commonly used method of sending data to the computer is by using the keyboard. This is a character-oriented method that's based on written human communication.

Not long ago, users communicated with computers on a binary basis, using only values of 0 and 1 (off and on). Obviously, this method would make it impossible to use many of today's applications, such as word processing programs.

The effectiveness of input and output devices depends on the skill of the person using them. For example, the fastest keyboard isn't very helpful if you're a two-finger typist, and whether you like or dislike using a mouse may depend on personal preferences as much as on the size of your hand.

In the following sections we'll provide an overview of your PC's input and output devices.

Ports

The PC's ports aren't actually input or output devices. However, we've included them in this chapter because they are the only link between the PC and such devices, and, therefore, to the "outside world." Ports transfer information between the PC and its peripherals.

Parallel vs. serial data transmission

Ports use either parallel or serial data transmission. In parallel data transmission, several bits of information (usually eight, which form a byte) are transmitted simultaneously over eight separate conductors.

Serial transmission, however, uses only a single channel, so all bits of information must be sent one after the other, or serially.

Obviously parallel data transmission is the faster method. For example, an 8-bit parallel port's transfer rate is ten times faster

than a serial port's transfer rate. This is partly because serial transmission uses several control bits, which slow down data transmission.

However, an advantage of serial ports is that only a few conductors are needed. This results in thinner, more affordable, and more durable cables. Because of this, longer connections are easier to achieve with serial conductors than with parallel conductors.

A PC system can have a maximum of three parallel ports (LPT1 through LPT3) and four serial ports (COM1 through COM4). Also, PC systems usually have a serial keyboard port and a game port, which provides a special connection for two analog joysticks. Most PCs are shipped with one parallel port, two serial ports, and usually a game port that's located on a separate expansion card instead of on the combination controller.

The system assigns individual port addresses and specific hardware interrupts to these ports. Data input and output is then conducted through the corresponding port address. Interrupts play a slightly more complicated role. Through these special channels of the system bus, it's possible to interrupt the CPU while it's performing its current task and to demand its attention elsewhere. This type of interrupt is used, for example, when you move your mouse pointer across the screen. The pointer must move when you move your mouse, instead of when the processor has completed its current task.

The distribution of port addresses and interrupts is predetermined. However, everyone doesn't follow this predetermined arrangement. The reason for this is the division of the AT bus.

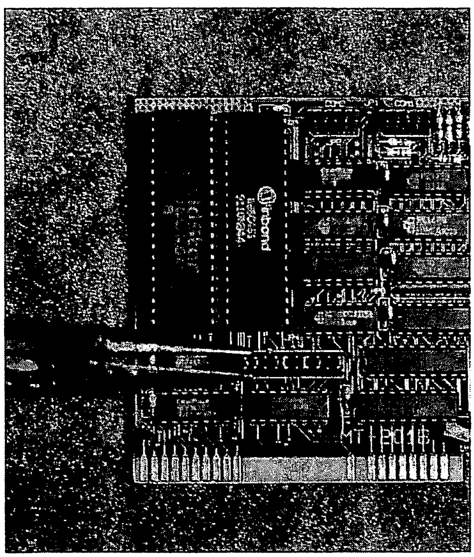
The two interrupt channels IRQ10 and IRQ11, which are assigned to the serial ports COM3 and COM4, are located on the 16-bit segment of the bus (i.e., on the shorter portion of the expansion slot). However, since most port expansion cards are designed for 8-bit slots, they cannot use these IRQ channels. Therefore, other IRQs are used, although these may already be assigned to other ports.

So, the addition of further ports on an 8-bit bus can easily lead to a shortage of available hardware interrupts.

The resulting problems can be solved in one of two ways. It's possible, under the right conditions, for two ports to share the

same hardware interrupt. However, it's also possible that some ports don't need interrupts. The deciding factor in both instances is the type of device attached to the appropriate port. Many devices don't need an interrupt to operate. For example, parallel printers can operate without a hardware interrupt.

The mouse, however, must use an IRQ. If the mouse port, which is usually COM1, is forced to share an interrupt with another port (for example, COM3), the device attached to this second port cannot use the interrupt because the system will crash. Therefore, you cannot operate a modem and a mouse on the same IRQ.



Port expansion card with configuration jumpers

Generally these port expansion cards will be equipped with several jumpers or one or more DIP switches that allow you to configure the card. You should refer to the documentation supplied with the card or a suitable test program, such as CHECKIT, to determine the exact correlation of IRQs and ports.

Most cards allow you to define the port addresses and interrupts for the ports built into the card. For example, if you want to add a third serial port to your PC, you'd be able to define it as COM4 and assign either IRQ3 or IRQ4 to this new port. This configuration isn't unrealistic. For example, if your system is equipped with an internal modem, COM3 might be occupied already.

When installing a multi I/O card, a card with two serial ports, and one game port, you must consider the game port. If your system already has a game port, you must disconnect it before installing the card. This is necessary because a second joystick is accommodated by a Y-splitter, which uses a single game port, instead of by a second game port. You cannot install a second game port on your system.

Keyboard

The keyboard is the most important input device of your PC. Because of the increasing popularity of graphical user interfaces, such as Microsoft Windows, the mouse is being used more frequently. However, the keyboard is still the primary way to enter data.

Except for graphical applications such as AutoCAD, the information or data of almost every application is character-oriented. For example, word processors, databases, spreadsheets, and desktop publishing (DTP) programs process letters, numbers, and other characters.

Keyboards are specifically designed for entering these characters and are still the fastest way to perform this task. Acoustic character entry, or speech recognition, is still being developed. Even text entry through OCR (Optical Character Recognition) programs, which basically "read" by recognizing certain shapes as specific characters, first require a written or typed text. This original copy is usually created with a keyboard.

Basic function

A PC keyboard consists of a series of keys or switches that are mounted in a case. Each of these switches doesn't have to be connected to the PC with a separate wire because a special electronic circuitry is also located in this case. This circuitry enables the information entered on these keys to be sent to the PC through a serial cable.

For this purpose, each key is assigned two codes. The make code is triggered when a key is pressed down and the break code is triggered when the same key is released again. This also enables the operating system to work with keyboards of different languages or arrangements, since a specific character is triggered only when the key code is received by the operating system.

The character assignments are stored in tables called code pages, which specify a particular character for each key code.

This is also how foreign keyboard drivers are used. The KEYB command simply loads the specified table, which is then used to assign the appropriate character to each code sent from the keyboard.

Configuring your keyboard

If you briefly hold down a specific key, the character that's assigned to that key will be printed repeatedly on your screen. This process is triggered by the keyboard processor. If this processor receives a key's make code but doesn't receive the corresponding break code within a certain time period, it outputs this key code repeatedly.

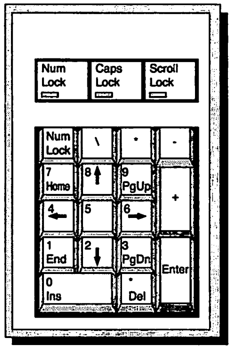
The number of key codes that are sent per second is also referred to as the typematic rate. Several utilities let you change this rate.

TIP

The delay, after which the repeated output of the character is triggered, can also be adjusted. With some PCs, you can adjust this value in the BIOS setup. In Chapter 8 we'll use an example to demonstrate this procedure.

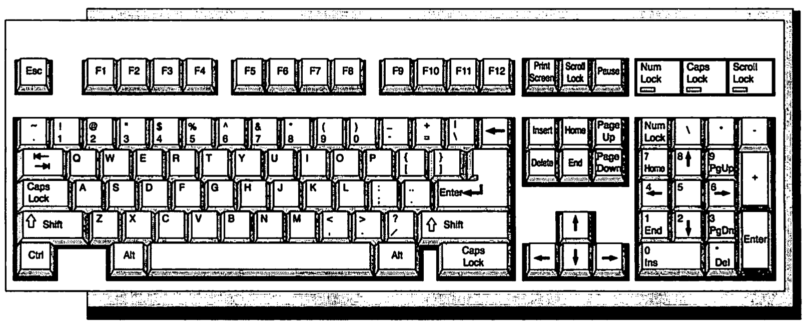
Standard layout

Today most PC keyboards look the same. They have 101 or 102 keys that are grouped into four areas. Above the main group, which contains the character keys, you'll find twelve function keys arranged in three clusters of four keys each.



On the right side of the keyboard is a numeric keypad, which can also be used to move the cursor. However, this function is usually performed by the special cursor keys that are located next to the numeric keypad.

The current keyboard status is indicated by a row of three LEDs, so you can always determine whether the Num Lock, Caps Lock, or Scroll Lock functions are active.



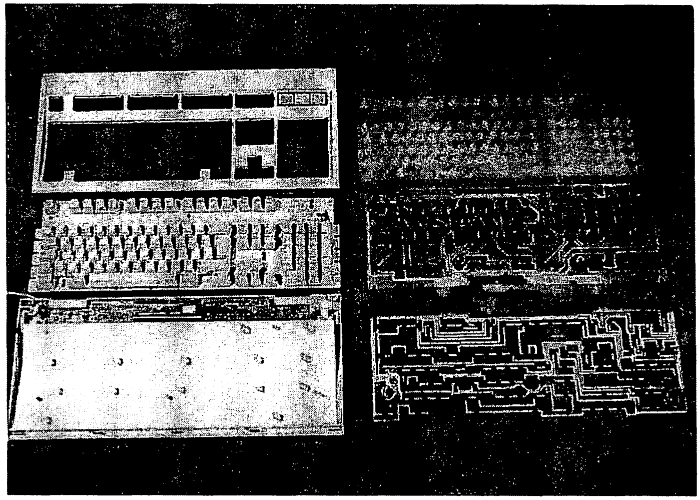
An example of an MF-II keyboard layout

The MF-II keyboard layout is based on the expanded AT keyboard by IBM. Since this layout has been so popular, it now represents the industry standard. However, this keyboard layout isn't particularly ergonomic or efficient.

Attempts to introduce a more ergonomic layout, in which the keys are easier to reach, haven't been successful. Since most users are accustomed to the layout found on a typical typewriter, using different layouts on a PC keyboard usually cause confusion.

Keyboard construction

The biggest difference between various keyboards is the way they are constructed. The construction of the key contacts, in particular, varies depending on the manufacturer.



The interior of a foil keyboard

Foil contacts

Since keyboards that use foil contacts can be produced easily and inexpensively, they are found in numerous PC systems. With this technique, two sheets of foil are imprinted with the actual contacts and their connections. These sheets of foil are laminated on either side of a layer of insulating material so the contact surfaces of the two sheets are separated slightly. Keys are mounted just above these contacts, and when one of these is pushed, the contacts below are pressed together, closing a circuit. A small spiral spring or a flexible plastic element is used to raise the key again after it's released.

This foil technology is so advanced that the reliability and life span of these types of keyboards can be compared to those of more expensive systems.

Metal contacts

Although keyboards with "real" metal contacts are more expensive to produce, they are found in almost as many systems as the foil keyboards. This technique uses individual switches for each key; metal tabs are pushed together when a key is pressed. Usually these tabs will be plated with gold or another non-corrosive conductor to prevent the contacts from becoming fouled. As with the foil system, metal or plastic springs are used to push the key back up once it's released.

Touchless keyboards

The most elaborate and, consequently, the most expensive technology is found in touchless keyboards. Three different methods are used for these systems. The piezoelectric method uses the piezoelectric effect, by which crystal tiles produce an electrical voltage when pressure is exerted on their surfaces. This type of keyboard has a small piezo-crystal under each key. So each time a key is pressed, a small electrical voltage is produced by the crystal below.

This voltage can then be registered and processed by the keyboard circuitry. The optoelectrical method uses light-gates mounted below each key to detect keystrokes. Pressing a key blocks the light gate below. Since this method is both expensive and fairly unreliable, it's used only in certain industrial applications.

The magneto-mechanical method, using the HALL effect, is used much more frequently. In these systems, a small permanent magnet is mounted on the underside of each key. When a key is pressed, its magnet is brought near a HALL sensor. The magnet produces a change in the electrical state of the sensor that's then detected and processed by the keyboard circuitry.

On a good keyboard you should be able to feel when a character has been activated. The keys should either have a distinct pressure point or a very clear stop, and the characters should be triggered at exactly that moment. This doesn't happen on many keyboards. In these instances, simply touching a key lightly may trigger the character, even if the pressure point hasn't been reached.

Adjustments

Your keyboard shouldn't move when you're typing. This usually happens with inexpensive keyboards. To ensure that this doesn't happen, the keyboard should be fairly heavy, or should have a non-skid underside. Also, your keyboard should be adjustable so its position is comfortable for typing. Many keyboards have two feet that raise the back of the keyboard so it tilts toward you.

Keyboard cables that are too short can also be an annoying problem. However, this problem can easily be solved by purchasing a special extension cable.

Since each user has different needs and preferences, a single keyboard won't meet everyone's needs. So when you're looking for a keyboard, consider its overall quality and then try it out thoroughly.

Mouse

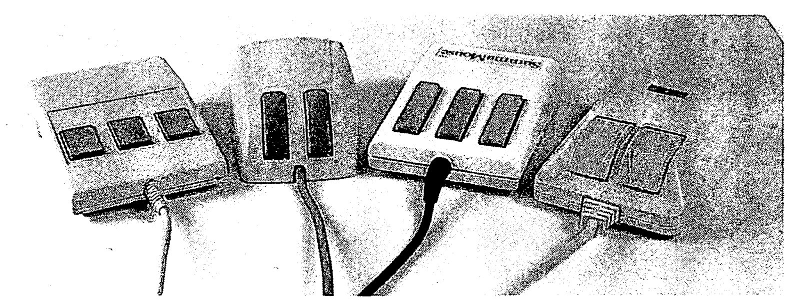
In addition to the keyboard, the mouse is an important input device in the PC system. The mouse has become an indispensable tool for working with graphical user interfaces and creating drawings and graphics. This is especially true with user interfaces such as Windows.

Records or enters movement

The mouse is used primarily to record or enter physical movement. It basically consists of a small box that can be moved in any direction on either the surface of your desk or on a special mouse pad. This movement is registered by the PC system, evaluated by a special program, called the mouse driver, and passed on to the application program. Most applications indicate the relative position of the mouse on the screen with a small arrow known as the mouse pointer.

Mouse buttons

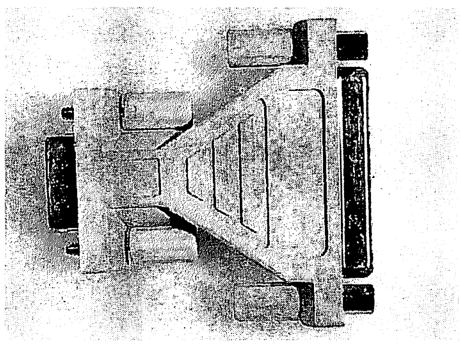
The mouse pointer can be moved to any location on the screen by moving the mouse on a flat surface. For example, you would do this to select a particular menu item. This item can then be activated by pressing one of the buttons that's built into the mouse. Most mice have three of these buttons, which are located on top of the mouse. However, few applications use the middle button. Because of this, some manufacturers don't include this button on their mice.



Four different PC mouse types

Connecting a mouse

The mouse is usually connected to an available serial port, which is usually COM1. When purchasing a new mouse, ensure that it's equipped with the correct plug since there are two different standards. Most systems use a 9-pin sub-D connector. This is the connector that's used for the first serial port in most PC systems.



A 25 to 9-pin adapter

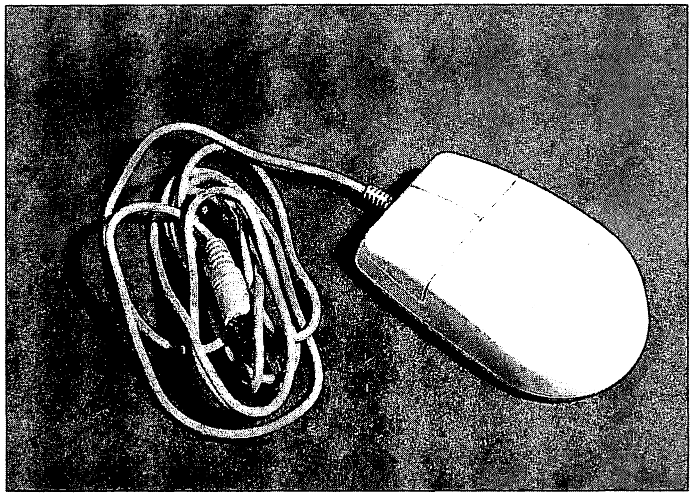
However, there also 25-pin mice. With these mice you'll need an adapter for the 9-pin plug. This adapter, which is usually attached to your PC's jack with screws, can protrude from the back of your PC.

So, if you're planning on or are forced to place your PC directly against a wall, you should either purchase a different mouse or plug your mouse into a port with the proper connector, perhaps COM2.

It's also possible that a 9-pin mouse plug must be connected to a 25-pin jack. Remember that some PCs aren't equipped with a 9-pin serial port; often COM1 is also found in the form of a 25-pin jack. Appropriate adapters can be used in this case also. Sometimes these adapters are even supplied with the new mouse.

Bus mice

Some mice, also known as bus mice, aren't connected to the PC through a serial port. Instead, they are plugged into the PC's bus system directly using a special expansion card. Often you'll find an appropriate mouse connector on other types of expansion cards, such as graphics cards or combination controllers.



A bus mouse with its jack

There are two different versions of this system. Among other things, these versions differ in the type of connector used for the mouse. So, if you want to install a bus mouse and are already using a certain type of connector, ensure that your new connector will be compatible with your existing jacks.

In both instances, the mouse must be registered with the system through a special mouse driver. This device driver should be included on the diskette that's shipped with a mouse. You must either add this driver as a DEVICE entry in your CONFIG.SYS file or, if it's an EXE or COM file, load it from the operating system environment. In the latter case, it's easier to perform this task in your AUTOEXEC.BAT file. By doing this, you don't have to remember to load the driver each time you use an application that requires the mouse.

Microsoft vs. Mouse Systems

Two different types of data formats are used in mouse systems: Mouse Systems mode and the Microsoft mode. These systems have different hardware and driver software.

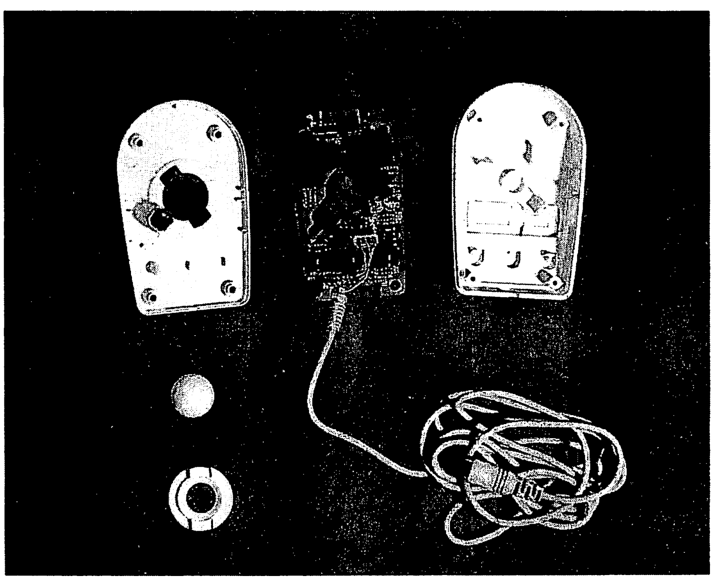
Most mice will allow you to switch between the two modes. However, you may also need to install a different mouse driver, depending on the mode used.

Your application must also be configured for the mouse mode that you're using, which can be a complicated process. Over the past few years the Microsoft mode has become the standard; most applications can be driven with a Microsoft-compatible mouse. So, you shouldn't encounter any problems if your mouse isn't able to operate in Mouse Systems mode.

The basic structure of a mouse

When you move a mouse across a flat surface, a rubber or plastic-coated steel ball, which is recessed in the underside of the mouse, registers this movement. This ball then transfers this movement to two rollers that divide the movement into separate vertical and horizontal components.

The rotation of these rollers is registered electronically and is transformed into impulses that can be evaluated by the PC. The roller movement is generally captured by using a mechanical method or an optoelectronic method.



The internal components of a mechanical mouse

The mechanical method uses a gear to constantly open and close an electrical contact while the mouse is being moved. The frequency of the impulses created in this way depends on the rate at which the

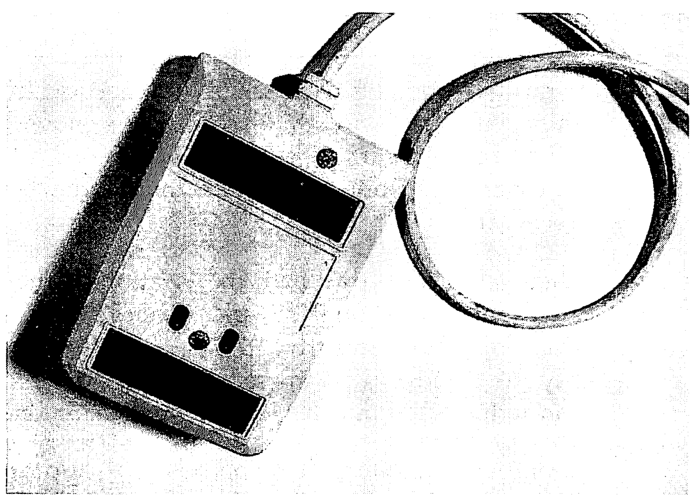
mouse is being moved. This value is then evaluated electronically and processed further.

The optoelectrical method, which actually uses a very similar technique, is not only more reliable, but also more durable. This method also alternately opens and closes a switch. However, the switch used in this process consists of a light gate that registers the motion of a small wheel lined with holes. This method is almost entirely free of wear and tear, has a higher resolution, and is protected from dust and dirt.

Optical mice

Although quite expensive, another type of mouse, which is constructed without any moving parts, is also available. This type of mouse uses an optical method to register movement.

The bottom of this mouse contains two or more photo transistors as well as at least one light source (usually a light emitting diode (LED)). With this type of mouse, you must use a special mouse pad, which is imprinted with a fine grid of lines or matrix of dots.



The bottom of an optical mouse

The pattern on the mouse pad is scanned by the photo transistors and is transformed into a standard mouse signal. This technique protects the mouse against wear and tear and dirt particles. Also, it offers very precise positioning.

Wireless mice

The mouse wire that connects the mouse to the keyboard bothers many users. Therefore, some manufacturers offer wireless mice. These mice transmit the mouse data either through radio waves or, more commonly, through an infrared signal. A receiver is connected to the PC, similar to a normal mouse, at one of the computer's serial ports.

The wireless mouse contains both the transmitter of this signal and a battery to provide power for this transmitter. This battery must be changed regularly, which is a disadvantage of this system.

Usually the system includes a special fitting that's integrated into the transmitter and supplies the mouse battery with electricity.

Unfortunately this charging unit operates only when the PC is switched on. So the mouse cannot be used during much of a computing session. Some manufacturers avoid this problem by supplying several exchangeable batteries that can be charged separately.

The trackball

A trackball operates like a mouse on its back. It's extremely useful when there isn't enough space to use a mouse. Instead of being moved across a surface, a trackball is moved by using the palm of your hand or your finger tips to roll the trackball within its special fitting.

When selecting a trackball, the location of the mouse buttons is important. You should be able to operate these buttons without removing your hand from the ball. Otherwise, it would be very easy to accidentally move the ball. So, you should always thoroughly test a trackball before purchasing one.

Recently many trackball keyboards have appeared on the market. These keyboards combine the two primary input devices, the mouse and keyboard, into one unit. However, to control the size of the keyboard, some of the keys may be eliminated. Usually the cursor keys are removed or moved to another location.

Joystick

Like the mouse, the joystick enables the PC to register motions or different positions. Although these devices perform basically the same function, they operate very differently and are used with different applications.

Joysticks are used mainly with computer games. Until recently, this area of computing was limited to Amiga, C64, or Atari users. However, because of the significant increases in performance and the excellent graphics of the VGA standard, IBM compatible PCs are now part of the computer game field.

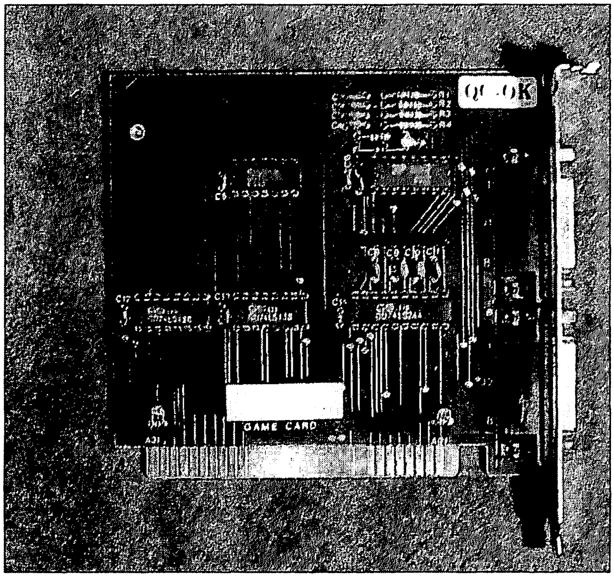
Many of today's computer games, especially simulators, either require a joystick or are significantly improved by using a joystick.

Connecting a joystick

The PC has a port that's specifically designed for connecting a joystick. This game port can be used to connect up to two joysticks, although most PCs are equipped with only a single 15-pin sub-D connector. So, if you want to connect two joysticks, you'll probably need a fitting Y-connector, which you can find in most computer stores.

If your PC doesn't have a game port, you can easily add an appropriate game port expansion card. Usually this card includes two connectors that enable you to use two joysticks. However, first you should determine whether a game port is hidden somewhere in your PC system.

Occasionally this port must be activated by changing a jumper setting on the port expansion card. If your system has a sound card, it's possible that the game port is included with this card. In this case, the game port simply must be activated.



A game port card for two joysticks

WARNING

Never try to connect two game cards to your PC at the same time. Doing this not only doesn't work but may also damage or destroy the cards or other components of your system. However, two joysticks can be used with a single game port.

Is your PC too fast?

Many 386 and 486 systems, particularly those with external caches, may encounter problems when a joystick is used. This happens when the port addresses are read so quickly that the game card can't keep up. In these instances you must use a special high-speed game card, such as the ones produced by Gravis. This company also produces special joysticks which should, when used with their game card, solve any potential speed problems.

The presence of a joystick doesn't need to be registered with the system; the joystick is simply plugged in. Certain test programs should be able to detect the presence of a game port. However, if you're using such a program, its test results may not match your

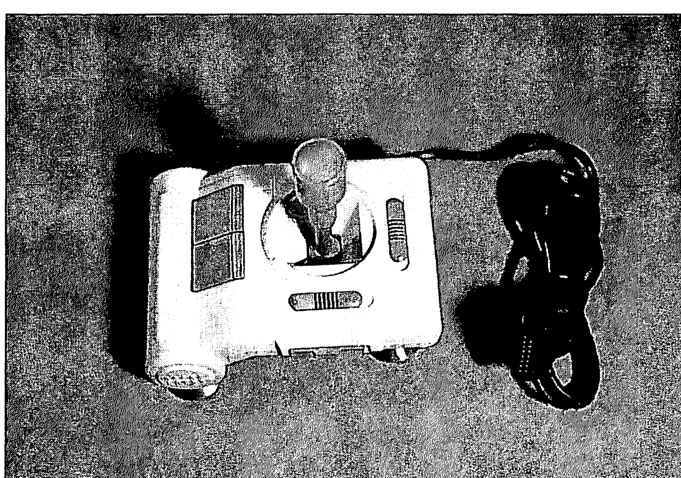
system's actual configuration. We've found that all game ports aren't recognized by these programs, and that not every game port that's reported actually exists.

The structure of a joystick

A joystick consists of a small lever that's mounted on two rotational axes and placed in a plastic case. This case also contains two buttons, called fire buttons. The lever is moved forward and backward as well as side to side. This is similar to the control column of an airplane, which was used as a model for the joystick.

A potentiometer, or variable resistor, similar to the one used in the volume knob of a radio, is mounted along each rotational axes. When the lever is moved, the change in position results in a different electrical resistance in the corresponding potentiometer, which is registered by a small electronic circuit. This circuit produces a signal in accordance with the measured resistances and sends this signal to the PC.

This technique distinguishes PC joysticks from most of the inexpensive joysticks that are used in many video games and home computers. The joysticks used in these instances are generally digital joysticks that register the joystick position with simple micro switches or electrical contacts. This means that these joysticks don't permit gradiated settings. So it would be impossible to control a flight simulation program with this type of joystick.



A joystick with fire buttons and adjustment sliders

Several joysticks include some useful features. Trim adjustments are particularly helpful because they enable you to adjust your joystick's central or zero setting. Most joysticks use sliders or knobs, in addition to the standard joystick lever and the fire buttons, to do this. However, these adjusters shouldn't be accidentally bumped while the joystick is being used. Another useful feature allows the joystick spring to be deactivated, so the joystick maintains its position instead of returning to the center setting each time it's released.

Scanner

A scanner enables you to digitize pictures or graphics, such as photographs or news clippings. The existing picture is scanned by light-sensitive semiconductor elements (LDRs). The signal from these elements is transformed into a sequence of bytes that's read into RAM. From there, the sequence can be sent to the screen or stored in a file. Affordable hand-held scanners, whose quality and performance have improved considerably in the last few years, have made this technology accessible to many PC users.

Connecting a scanner

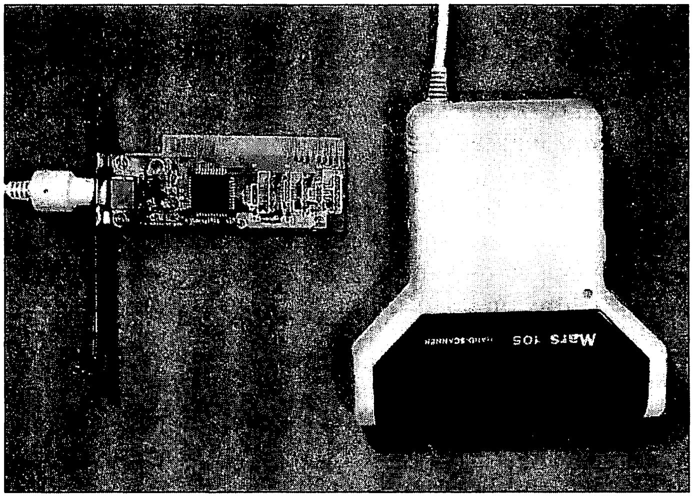
Requires interface card

To use a scanner, you need a special interface card that transmits the information read by the scanner to the PC. Since this is usually an 8-bit card, a short expansion slot is sufficient for installing the scanner. The different scanner manufacturers use entirely different data transmission methods. So, usually it isn't possible to operate a scanner on an interface card from a different manufacturer. Apparently the connector from the scanner to the interface doesn't fit.

If the channel is full

Most scanner interface cards use the DMA system. This means that the card places information, sent by the scanner, in a reserved memory area. The active software can then access this data from this area. Although most interface cards allow the DMA channel to be selected through a jumper setting, usually the default setting doesn't have to be changed.

Most cards are configured correctly by the manufacturer. However, if your system encounters a DMA conflict once you've installed your scanner, you should select a different DMA channel with the settings on your scanner card.



A hand scanner with accompanying interface card

Unfortunately this procedure differs, depending on the scanner. So you must refer to the documentation provided with the scanner if you need to change the default configuration. If you're not sure how to configure the card, simply try different settings. However, be sure to write down the initial settings before making any changes.

Usually a second jumper setting also allows a port address to be selected for the scanner card. Again, the initial settings are usually correct. You'll need to change the default port address setting on one of the conflicting cards only if your system includes other expansion cards that use the same address, such as a network or sound card.

Often, to use older scanner systems, an available hardware interrupt (IRQ) is needed. In this case, you'll encounter a problem with 8-bit adapter cards. This is the same problem that occurs when installing additional ports. Only the first 8 IRQs are available on an 8-bit slot, and these are often already used. Conflicts usually occur with the printer interface, which uses either IRQ7, like it should, or in other cases IRQ5. So, you should set your scanner card to the interrupt that isn't being used by the printer interface. If you don't have a test program that can tell you which interrupt is being used by the printer interface, you may want to try IRQ5 first.

Also, your scanner card may be able to share the interrupt of the second serial port (COM2), interrupt IRQ3.

Once you change a card's port address, DMA channel, or an IRQ, you may need to reinstall or reconfigure all the software for that card to activate the new settings. Changes in the settings of network cards are especially complicated. In this case, you may need to reinstall the entire network. So, you should make these changes only if you cannot correct the conflict by changing the setting on the other card, which in this case is the scanner card.

Selecting a quality scanner

Before you can select a quality scanner, you must understand the terms DPI and gray scales. We'll use the following example to explain these terms.

Suppose that you want to scan a 10 by 10 inch picture at 800 DPI (Dots Per Inch) resolution and with 256 gray scales. To do this, you'll need 64 Meg of available memory. The display of 256 gray scales requires one byte per pixel (dot). So the picture previously described would be scanned with a total of 64 million (8000 x 8000) pixels.

If you want to print a hardcopy of the picture at this resolution, your printer must display a 16 x 16 dot-matrix for each pixel to display 256 shades of gray. This is necessary because printers can duplicate gray scales only by printing dots at varying densities. Even if a laser printer with a resolution of 300 DPI is used, the resulting printout would measure 8000x16/300, or almost 430 inches (almost 36 feet) on each side.

So your final printout would cover over 1200 square feet and require over 1970 sheets of paper. Also, at a printing rate of 4 sheets per minute, the entire printing process would take about 490 minutes, or more than eight hours.

As we tried to illustrate with the previous example, a good scanner isn't necessarily characterized by an amazing resolution or many gray scales. Even if a scanner did have these capabilities, the demands placed on the PC system would be overwhelming. These capabilities would be useful only if you want to scan extremely small items, such as postage stamps, and then enlarge these images.

In most cases, a scanner with a 300 DPI resolution and 16 gray scales is sufficient. If you calculate the results that are possible with this resolution, you may even decide that a scanner without any gray scales is acceptable.

A scanner is only as good as its program

A more important indicator of a quality scanner is the software that's supplied with it. Usually this is the most disappointing feature of a scanner. Often the software won't be able to use extended memory, or it won't be able to store portions of a picture, that's being scanned, on your hard drive.

Check carefully

Because of the limited amount of conventional memory that's used with these programs, only an extremely small picture format can be scanned. So you should always determine whether the software supplied with a scanner is actually able to live up to the performance advertised by the manufacturer.

Another useful feature of some hand-held scanners is a guide rail that allows you to scan originals in a straight line. This simple tool significantly improves the reproduction quality.

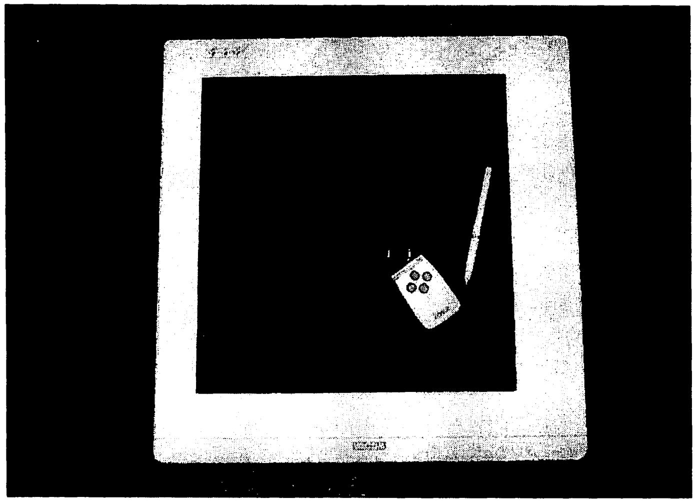
Digitizing tablet

A digitizing tablet, also called a graphics tablet, is a special input device that's mainly used to digitize vector-oriented drawings or pictures.

The original image is simply traced with a special pen or a device similar to a mouse that's equipped with a magnifying glass and a pair of cross-hairs.

The position of the pen or the cross-hairs is registered by the actual digitizing tablet, which is placed below the original drawing. This is usually done by charging the pen or pointer with electricity, which causes a change within a constant electromagnetic field. This flux is then evaluated and transformed into usable data.

This technique is similar to that used with a light pen, except that this is a collection of hundreds of these systems. A fairly complex electronic circuit is used to collect the information from these individual systems and transform it into a serial signal that can then be sent to the PC over a normal COM port.



A professional graphical pad

Digitizing tablets are used primarily in professional graphics applications, for example by designers, architects, or technical draftspersons. Unlike a mouse, a digitizing tablet provides a higher level of precision with which the pen or pointer can be positioned. However, this isn't important to most PC users.

Since digitizing tablets can cost thousands of dollars, most PC users can't afford them. Several less expensive versions have been introduced recently but their effectiveness for professional applications is questionable.

Before you purchase a digitizing tablet, you should thoroughly test the equipment under the conditions under which it will be used (i.e., with the software you'll be using). If you're planning to replace your mouse with this device, you must find a mouse driver that's designed for that specific graphical pad, since not all pads are capable of operating in a completely Microsoft-compatible mode.

The more expensive digitizing tablets offer several useful features that increase its effectiveness in professional applications. One of these features allows the original drawing to be secured or fastened in various ways. Some systems use a simple clamp, while others use more elaborate methods, such as electrostatic technology or a perforated surface combined with a vacuum system to hold the paper securely on the tablet.

Although it's an expensive option, using a cordless pen may increase your productivity by providing more mobility. This is especially important with large images.

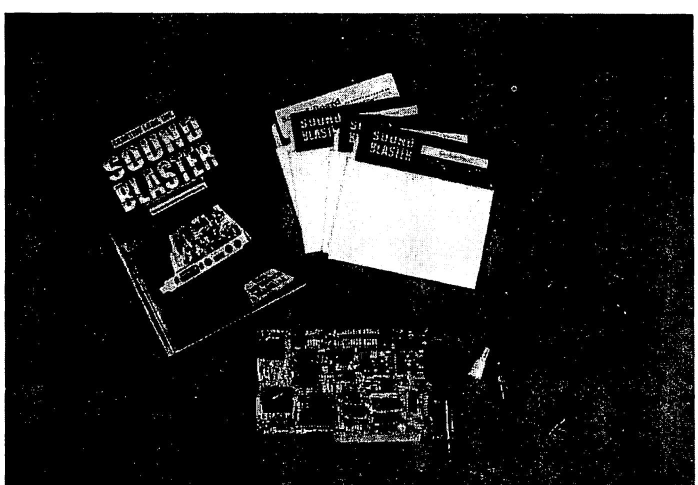
Sound card

When you boot your system, you hear a simple beep that's emitted from the computer's internal speaker. Unfortunately this was all the PC sound system was designed to do.

As the PC evolved, many programmers tried to produce more interesting sounds from this speaker. These programmers managed to produce multi-voiced music under certain conditions. However, the sound quality was very poor. Even at this simple level, sound output required a lot of processing time and data. So using background sound for enhancing programs such as games was very limited.

The most popular sound cards and generally regarded as the best are those manufactured by Creative Labs, Media Vision, and Turtle Beach Systems.

By adding one of the many available sound cards to your PC system, you can increase its sound capabilities. However, since so many cards are currently available, it's difficult to know which features to look for in a sound card.



A sound card with various accessories

Number of voices

The sound card is designed to replace the modest single-voice sound of the internal PC speaker with a multi-voice system that's capable of producing various sounds. Today's sound cards can produce from 9 to 44 different voices. The sound of each of these voices can be controlled individually and can then be played back simultaneously. Theoretically, the more voices a card is capable of producing, the greater sonic or tonal richness it will achieve.

Sampling capability

If a sound card has sampling capabilities, it's able to play back and, in some cases, record digitized sounds or sound samples. This feature is particularly useful with certain sounds, such as a snare drum, which are almost impossible to create through pure sound synthesis. Using a DAC (Digital to Analog Converter) solves this problem.

Several cards also include ADCs (Analog to Digital Converter), which transform analog signals to digital samples. These cards are equipped with microphone inputs so sounds can be sampled directly.

The sampling rate determines the quality of a sound sample. This factor determines how many analog values are digitized each second in a sound sample. The highest frequency that can be played back by a sample is exactly half of the sampling rate used.

For example, to reproduce a frequency range up to 6 KHz, a sampling rate of at least 12 KHz is needed. The other factor that affects the quality of a given sample is its sampling depth, which determines how many bits are used by the converter in encoding the analog signal.

Although 16-bit and even 24-bit converters are available, usually 8-bit DACs are used. However, none of these converters can turn an existing 8-bit sample into a 16-bit signal. So, a larger converter is useful only when the samples are made by the same sample width that's used to record the samples.

Unfortunately, the amount of data required for a sample increases with the sampling rate and the sampling depth of the sample. So, a sample file of 11025 x 60, or 661500 bytes, is needed to play back a minute of spoken text at the realistic sampling rate of 11.025 KHz

on an 8-bit DAC. Because of this, several sound cards contain a compression device that reduces the size of these files.

Stereo/mono

Although stereo sound is an excellent expansion of the capability of any sound card, most sound cards are strictly mono cards. Only a few of the cards on the market are sold as stereo cards. Other cards can obtain stereo capability through upgrades. You'll find that a stereo amplifier is included in some cards but the actual sound card can produce only mono sound. Later we'll discuss the limitations involved in using stereo sound.

Accessories

The accessories available for a sound card vary depending on the manufacturer. Not every card is equipped with a high-quality audio amplifier, so you must connect the card to your home stereo amplifier if you want to play the sound over a stereo speaker. Several manufacturers even supply one or two external speakers and occasionally a microphone with their sound cards.

Although you shouldn't expect too much from these accessories, you may be pleasantly surprised by the sound quality that can be achieved with today's sound cards. Even the sound produced by connecting a stereo speaker to a sound card amplifier produces convincing results.

To obtain the best results, you should connect the card to your stereo system. Unfortunately, none of the cards we've used includes a cord that's long enough to reach from your PC to your stereo. So if you want to set up your sound system in this way, you'll probably need an audio extension cord.

One accessory that's been overlooked by sound card manufacturers is an external volume knob, which would solve the problem of reaching behind the PC to adjust the card's volume setting.

The application is the deciding factor

Before you rush out to buy a sound card with several voices, a high sampling rate, stereo sound, and many other features, there are some criteria you should consider. The application you'll be using is the most important factor in determining which sound card is best for you.

Although sound cards are mainly used with computer games, it is with these applications that sound cards are most limited. This is because the majority of computer game manufacturers don't completely use the large selection of cards or their capabilities. Many games support only the few sound cards that are considered standards.

The Sound Blaster card

Since the AdLib card is the oldest sound card, it's supported by the most programs. However, since this card has only 11 voices and no sampling capabilities, it isn't exactly versatile or powerful. In spite of this, only AdLib-compatible cards are successful in the sound card market. One of the most popular AdLib compatible cards is the Sound Blaster card. In addition to AdLib emulation, this card is equipped with a sampling channel that's capable of sampling rates up to 44 KHz.

The Sound Blaster card contains two 4 watt amplifiers and a stereo chip can be purchased optionally. However, since many programs don't use this option, you probably shouldn't purchase this chip, especially if you're interested in only improved game sound. The Sound Blaster card is supported by most software manufacturers and it's always possible to switch to AdLib mode. Because of its universality, the Sound Blaster card is still today's standard for PC sound cards. So, many new cards are also Sound Blaster compatible.

Multimedia demands more

The new set of MPC (Multimedia Personal Computer) standards created by Microsoft has set a new direction for the world of PC sound cards. These standards establish specific formats for sound output. However, none of the available sound cards meet all the requirements of the MPC standards.

We'll discuss these specifications in more detail when we discuss multimedia system configuration. However, Creative Labs has taken the lead in the realm of MPC compatible sound cards with its new Sound Blaster 16 ASP (Advanced Signal Processing).

Finally, we'll briefly discuss some of the problems that may occur when you add a sound card to your system. For several types of sound cards to operate properly, an IRQ must be available. To

avoid conflicts with other expansion cards in your system, select an interrupt that's not already being used by your printer port.

If, like Sound Blaster, your new sound card has its own game port but your system already includes a game port, you must deactivate one of these ports. Usually it's easier to disconnect the game port on the new sound card because the documentation for the card is readily available.

Occasionally the port address of your new sound card may cause address conflicts. Usually the manufacturer sets this address to 220 hex. If one of the expansion cards in your system is already using the same port address, you must configure one of the cards differently. When you do this, usually you'll have to reinstall the software for that card. So it's best to reconfigure the card that requires the fewest software changes.

16-bit sound

The standard for sound card reproduction was 8-bit, with an occasional foray into 16-bit sound. Now that PC sound technology has made some major steps, 16-bit sound recording and playback is the standard. One card with this capability is the Sound Blaster 16 ASP.

Sound Blaster 16 ASP

The Sound Blaster 16 ASP is Creative Labs' current high-end sound card. With 16-bit sound capability, the ASP (Advanced Signal Processor) chip for handling audio compression and decompression without taking up CPU time, 20-voice FM synthesis and Sound Blaster compatibility, the 16 ASP offers a low-cost option for high-quality PC sound.

Graphics cards

The monitor is an important interface between you and your PC. Your PC can communicate with you by displaying messages and information that it has processed. The status of an application is indicated through the monitor and you, in turn, make your entries based on the displayed information. So the monitor, along with the keyboard, enables you and the PC to exchange data.

The graphics card assembles the information that must be displayed on the screen. It acts as an interface between the

processor and your monitor. Like any other expansion card, the graphics card is simply plugged into one of the expansion slots on your PC's motherboard.

This connects it to the computer's bus system. The card sends the information, received through the bus system, to the monitor in the form of a video signal. This is why the term "graphics card" is used.

A graphics card consists of the video controller, the screen memory, or video RAM, and the character generator. The graphics card continually sends a video signal to the monitor. The video controller reads the information stored in video RAM at regular intervals and sends this information to the monitor as a video signal.

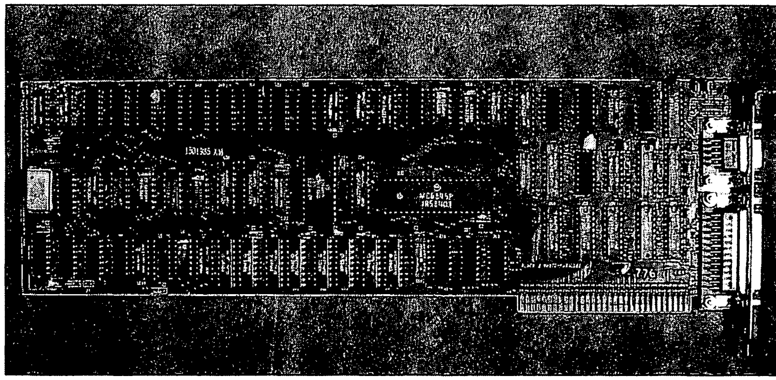
The number of times per second that the contents of video RAM are read and sent to the monitor as a video signal is known as the graphics card's screen redraw frequency. The frequency at which the screen is redrawn is one factor that determines a graphics card's quality. However, there are many other technical differences and standards, which we'll discuss throughout this section.

To understand the technical aspects of graphics cards, you must know the various video standards that have been developed. The following is a chronological overview of these standards and each corresponding graphics card.

Monochrome Display Adapter (MDA)

The first IBM PCs were equipped with a Monochrome Display Adapter (MDA), which could display only text. Although this card couldn't display graphics, this wasn't necessary at the time because PCs were mainly used to process text and numbers. IBM also offered a color graphics adapter (see below). However, this card was much more expensive and had poor text resolution.

The MDA had 4K of video RAM, which enabled it to display 25 lines with 80 characters each. The MDA's video ROM contains the pattern for each character in the ASCII table at a resolution of 14 x 9 pixels per character. The video controller reads the appropriate pixel matrix from video ROM, depending on the ASCII code of the character that must be displayed, and sends this information to the monitor as a serial signal.



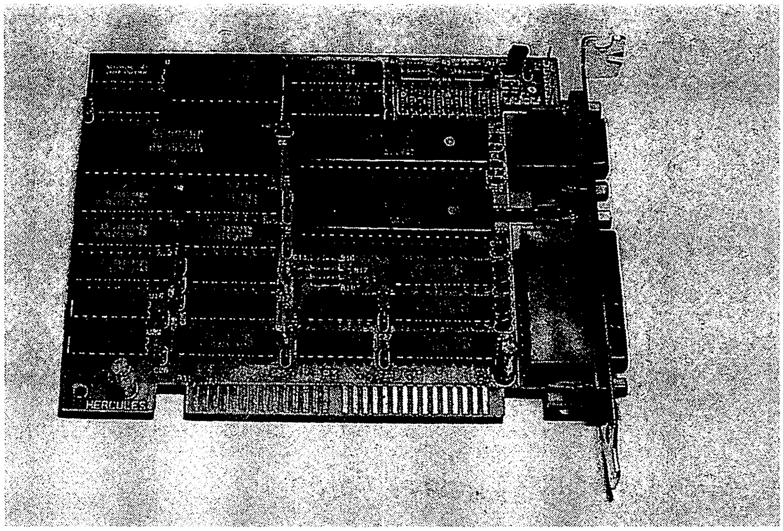
The Monochrome Display Adapter

Hercules Graphics Card

With the introduction of the Hercules Graphics Card (HGC) in 1982, users could finally display graphics and text on the screen simultaneously.

This graphics card was completely MDA compatible, supporting a text mode with a resolution of 80 x 25 characters, and also had a graphics mode with a resolution of 720 x 350 pixels. However, the Hercules card was suitable for only monochrome or single-color graphics.

Video RAM had to be increased significantly to permit a graphics resolution of 720 x 350 pixels. Each pixel on the screen is represented by a specific memory location in video RAM. This is easily accomplished for monochrome displays, since each pixel is either lit or not. In other words, the Hercules Graphics Card didn't have to store information about the color of each of these pixels.



Hercules Graphics Card and printer port

For the HGC, a monitor with 720 x 350 pixels is sufficient. So video RAM must have at least 252,000 memory locations, which corresponds to a capacity of about 31.5K. Additional memory is needed to display text and several other pieces of information. The Hercules Graphics Card had a total of 64K of video RAM.

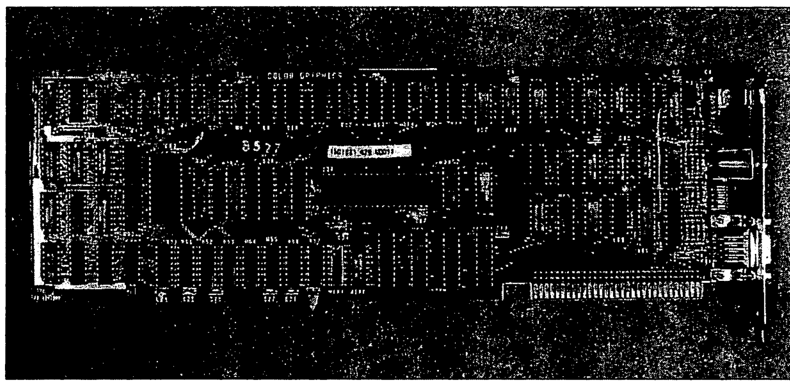
The 6845 video controller of the Hercules Graphics Card reads the contents of video RAM 50 times each second and redraws the entire screen. So it has a screen redraw frequency of 50 Hz (vertical scan frequency). At this frequency, the human eye is unable to register the redrawing of the screen. Since the video controllers of newer graphics cards redraw the screen even more frequently, they produce a more visually stable picture.

Because of its character matrix of 14 x 9 characters, the HGC is extremely well-suited for displaying text and numbers. Even the most advanced graphics standard (VGA) isn't significantly better than the HGC's text resolution.

However, the comparably low screen redraw frequency of 50 Hz isn't suitable for long computing sessions (over four hours daily) in front of the monitor. So the Hercules Graphics Card shouldn't be used in a PC workstation.

Color Graphics Adapter (CGA)

Since 1981 IBM has offered the Color Graphics Adapter for their PCs. The CGA was the first graphics-capable monitor adapter for personal computers. This card uses the same chip as the Hercules Graphics Card, the 6845 video controller. In text mode, the CGA operates the same way as the Monochrome Display Adapter, although the CGA card uses a character matrix of only 8 x 8 pixels.



The Color Graphics Adapter

So a text display of 80 characters over 25 lines doesn't have a very good resolution with the CGA. Because of this, the Color Graphics Adapter isn't a suitable graphics standard for text processing.

However, in graphics mode, the CGA provides different resolutions and colors. The display information for each pixel consists of a maximum of three color attributes. In this way, the three primary colors (red, green, and blue) are digitally combined into a maximum of 8 different colors (2^3). By adding an intensity value (bright-dark), it's possible to display 16 different hues (eight colors in two shades). However, not every CGA monitor is able to use this intensity value.

Unfortunately, resolution varies considerably depending on the CGA graphics mode that's used:

- 160 x 100 pixels with 16 colors
- 320 x 200 pixels with 4 colors
- 640 x 200 pixels with 2 colors

Using more colors decreases the resolution. The four color display is the most popular because it offers the best compromise between resolution and color display. The different graphics modes must be accessed and activated by the application software. The CGA card usually operates in text mode.

Sometimes poorly written software won't switch back to text mode once the program has ended. If this occurs, you'll notice that, for example, the cursor won't blink as it usually does in text mode. The DOS command MODE CO80 can be used to switch back to the standard operating mode.

Enhanced Graphics Adapter (EGA)

In 1985 IBM introduced the Enhanced Graphics Adapter (EGA). It's a high resolution graphics card that also has a better quality of color display. This expanded graphics adapter has a superior resolution compared to the CGA.

The EGA combined the operating modes of the MDA and CGA. Also, if you're using a color monitor, this adapter is capable of displaying all 16 colors in text mode with a resolution of 640 x 350 pixels. However, you can also display graphics on a monochrome screen.

In graphics mode, the EGA card offers two resolutions, 640 x 200 and 640 x 350 pixels. At both resolutions, 4 data bits are provided for color information. This results in a palette of 16 colors, if the card is equipped with 256K of video RAM.

Sometimes older EGA cards have only 64K of RAM, which limits the color selection, at a resolution of 640 x 350, to only 4 colors. Within the 256K of video RAM, exactly 89600 bits, or about 112K, are used for a picture with a resolution of 640 x 350 pixels and 4 color bits (16 colors). The remaining memory is used for the definition of up to four character sets, with 256 characters each.

You can simultaneously display a total of 16 colors from a palette of 64 colors on an EGA graphics screen. The character matrix of an EGA card, like the HGC, is composed of 14 x 8 pixels.

This high resolution of 640 x 350 pixels makes it possible for you to display either 80 characters in 25 lines or 80 characters in 43 lines. Since you gain 18 extra lines on your screen, this is a big advantage

in word processing and spreadsheet applications. Another improvement consists of smooth text scrolling.

Unlike the CGA, which shifted the contents of its video RAM to scroll text, the EGA simply shifts the screen border definitions within its video RAM.

An important difference between the EGA and the older CGA is that EGA cards have their own BIOS. After a cold start, the graphics adapter BIOS is activated; it even starts before the system's own BIOS.

First the graphics BIOS informs the system of its existence. Then it redefines the address for the video interrupt to its own address.

So, instead of being controlled by the system BIOS, as with the MDA and CGA, the video controller is controlled by the BIOS of the graphics card. The video BIOS basically operates as an extension of the system BIOS; it embodies the entire "intelligence" of the graphics card. It contains the program routines used by the video controller and generates the character sets.

For a long time, the EGA graphics standard was the highest graphics standard in the PC world. The manufacturers of EGA tried to outdo each other by creating more graphics modes and increased resolutions. Unfortunately, these individualized improvements cannot be used by many applications.

The EGA card usually operates in text mode. Its graphics modes can be accessed only by software that was written specifically for the EGA video controller.

To use the special capabilities of individual cards, a driver program is always needed to activate the card's own operating modes. Here you'll often encounter problems with "normal" application software.

Video Graphics Array (VGA)

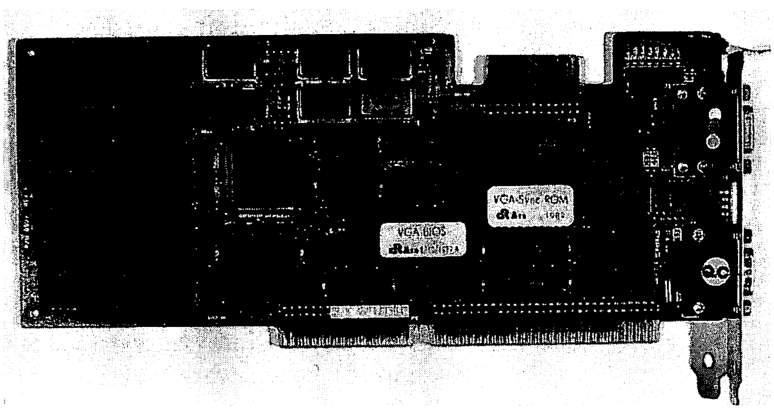
The Video Graphics Array card (VGA) began a new standard when it was introduced with the IBM Personal System/2 in 1987. Along with improved resolution, the Video Graphics Array (VGA) is capable of displaying 256 colors from a palette of 262,144 shades. It should be your choice if you're upgrading to a color monitor.

This graphics adapter clearly outperformed all of its predecessors, almost revolutionizing the graphics capabilities of the personal computer. No other graphics standard has been as widely used or has brought more significant changes and improvements with it.

256 colors out of 26144 choices

The success of this system is based on the VGA's impressive spectrum of colors. From a total spectrum of 262,144 possible colors, a palette of 256 colors is selected and stored in a color table. Each of these colors receives a code by which that color can be easily specified at any point on the screen. This color palette can also be programmed.

This results in much more colorful images. The large and user-definable selection of colors offered by the VGA has helped improve both PC applications and graphical user interfaces.



A VGA card

The VGA standard initially introduced by IBM specified a graphics adapter that sends an analog signal to the monitor at a screen redraw frequency of 60 Hz, with a resolution of 640 x 480 pixels and 16 of 262,144 possible colors.

Video RAM was first expanded to 512K, then 1024K. Because of this, extremely high resolutions of, for example, 1024 x 768 pixels with 8 color bits, are possible. However, the increased memory capacity of 512K requires a 16-bit connection to the PC's bus system.

Earlier graphics cards were available only in 8-bit formats because more wasn't necessary. However, now VGA cards are usually found in 16-bit formats. This format is referred to as the super VGA standard, although this standard has never been clearly defined or documented.

The VGA's text mode has a resolution of 720 x 400 pixels, which is slightly better than the text resolution of the Hercules card. Each character consists of a matrix of 14 x 9 pixels. So the VGA card has a better text display than other graphics cards.

Because of this, the VGA standard is the best graphics card for long computing sessions. Since it's fully compatible with all of its predecessors, it can emulate each of the previously described standards. So, software that was designed for older graphics cards can be used with the VGA standard.

Analog monitor signal

The main difference between the VGA and its predecessors is the way in which information is sent from the graphics card to the monitor. While each card from the MDA through the EGA has used a digital signal, the VGA emits an analog monitor signal.

Let's illustrate this by using an example. We'll compare a normal light switch with a light dimmer. Like a digital signal, the switch can be in only one of two positions, on or off. However, the dimmer is capable of any number of settings between full on and full off, which is comparable to an analog signal.

The CGA and EGA color graphics adapters could send only three different signal components to the monitor: (r)ed, (g)reen, (b)lue, and (i)ntensity, which results in a RGB+I signal based on the three primary colors.

Four additional signal components are formed by the transmission of no red, no green, no blue, and no intensity. Each of these four signals can therefore be transmitted digitally, for example as "red" or "no red." The screen contents were then assembled from the presence or absence of these signal components.

Analog signal transmission is also able to transmit values with varying RGB components. The intensity component can also be varied from bright to dark, similar to a light dimmer.

This allows the VGA card to create and transmit any number of combinations of primary colors and intensity values. The advantages of analog over digital signal transmission are what allows the VGA to provide numerous color combinations.

Every VGA card is equipped with a digital to analog converter that creates the analog signal. The video DAC used in VGA cards actually consists of three digital to analog converters, one each for the colors red, green, and blue.

Each DAC has a 6-bit data input and can therefore distinguish between 64 (2^6) different values. Since this means that 64 different variations of each of the three primary colors can be combined, the video DAC is capable of producing a total of 262,144 (64^3) different colors.

The connection to the monitor consists of three separate conductors, one for each color. The signal amplitudes determine the shades of the individual colors. A maximum amplitude signal in each of the three conductors illuminates the pixel completely, resulting in a white dot. A minimum amplitude signal in each conductor results in an unlit pixel, or a black dot.

The VGA chip and its components

Every VGA card has a central VGA chip. This chip determines the quality and performance of a VGA card. There are significant differences between chips from different manufacturers. In all cases, however, the VGA chip combines five different components, which we'll describe briefly.

The screen controller produces the horizontal and vertical synchronization signals. This controller, along with the VGA BIOS, varies these signals depending on the current operating mode of the graphics card.

The graphics controller is responsible for screen output in text and graphics modes. This component forms the bridge between video RAM, the attribute controller, and the CPU. In graphics mode it reads the contents of video RAM and sends this data to the attribute controller.

In text mode the graphics controller assigns the appropriate characters to the data read from video RAM before sending this information to the attribute controller.

The attribute controller assigns the specified colors to the data it has received from the screen controller via the graphics controller. It also controls the cursor, underline, and flashing functions.

The address/data multiplexer manages the transmission channels within the VGA chip. Data and addresses are transmitted over predetermined paths.

The sequencer controls the screen controller's and the CPU's access to video RAM.

The VGA BIOS and video RAM

Like the EGA card, the VGA has its own BIOS. This extension of the PC's system BIOS consists of up to three different EPROM chips. The video BIOS is responsible for generating the character sets and organizing the contents of video RAM. Also, it contains all necessary program routines.

As we mentioned, the amount of video RAM varies among different graphics cards. The minimum amount of video RAM on a VGA card is 256K. Today's 16-bit cards have 512K of memory.

As you may know, only 128K of the PC's system memory are reserved for video memory. So it's possible to address a maximum of two 64K address blocks simultaneously. To do this, the physical video RAM contained on the graphics card must be divided into a maximum of eight address levels, depending on the amount of memory installed on the card. Remember that higher resolutions and larger color palettes usually require more memory.

Additional factors

However, a graphics card's memory capacity isn't the only factor that determines a graphics card's quality. The card must also be capable of high resolutions and numerous color selections. Not all cards meet these requirements. So just because a VGA card has 1 Meg of video RAM doesn't necessarily mean that it can actually produce a 1024 x 768 resolution with 256 colors. Whether a given card is actually capable of this depends, in addition to its video RAM, on the VGA chip and the card's video BIOS. This information can usually be found in the documentation included with each card.

The correlation between resolution, color selection, and the necessary amount of memory is easy to understand. You can calculate the amount of required video RAM by multiplying the number of columns by the number of rows for a given resolution. So, a resolution of 800 x 600 pixels requires at least 480,000 bits of memory. A resolution of 640 x 480 pixels, however, requires only 307,200 bits of video RAM. These values must then be multiplied by the color factor.

The color factor is equivalent to the number of color bits used, instead of the actual number of available colors. 256 colors correspond to 8 color bits (2^8) and 16 colors correspond to 4 color bits (2^4). So, to display a resolution of 800 x 600 pixels with 256 colors, a total of 800 x 600 x 8, or 3,840,000 bits of video RAM are needed.

This corresponds to a memory capacity of about 468K (8 bits = 1 byte, and 1,024 bytes = 1K). So a graphics card equipped with 512K of video RAM fulfills one of the requirements for displaying 800 x 600 pixels in 256 different colors.

Frequency is important

One of the identifying characteristics of VGA cards is the presence of up to 7 different quartz crystal fittings on the card surface. These quartz clocks generate the different frequencies required by the card's different operating modes.

The two most critical frequencies for generating the screen picture are the following:

- Line synchronization (horizontal frequency)
- Screen redraw (vertical frequency)

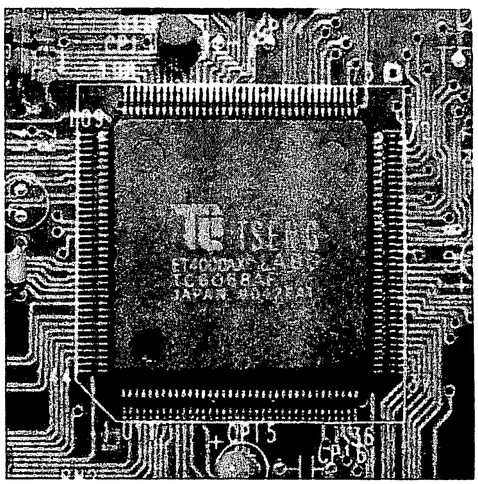
The vertical frequency, for example, determines whether the picture is stable (i.e., doesn't flicker). The picture appears absolutely stable to the human eye only at a screen redraw frequency of a least 72 Hz.

Most of today's simple, affordable VGA cards reach this value in their lowest resolution, at best. When they're switched to a higher resolution mode, the vertical frequency of many cards drops below 50 Hz or the card switches between two half screens instead of creating a full picture. The latter technique is known as Interlaced mode, which we'll discuss on page 154.

Special VGA chips

ET4000

Because users demanded more colors at higher resolutions, the first VGA cards were soon outdated. Special graphics chips began to appear on the market. One of the most popular chips is the ET4000 VGA chip from Tseng Labs. This chip is found mainly on VGA cards that have 1 Meg of video RAM. The ET4000 uses an exceptionally fast method to manage its video memory; it uses one quarter of the memory as a fast cache. This makes the ET4000 one of the fastest VGA chips available today.



The ET4000 chip by Tseng Labs

Super VGA (SVGA)

The Super VGA cards take VGA to new heights. Based on the VESA Super VGA Standard developed in 1990, Super VGA cards provide more colors in normal VGA graphics modes, higher resolution graphics modes (640 x 400, 800 x 600 and 1024 x 768), hardware cursors, and hardware zooming.

Graphics processors

A new generation of graphics cards even have a separate graphics processor. This means that the calculations needed to create a new picture are no longer performed by the PC's CPU. Instead, these calculations are performed by a graphics processor on the card. This processor is specifically designed for this task.

This decreases the amount of work that must be performed by the CPU, which results in a noticeably faster graphics output. The TMS 34010 and 34020 by Texas Instruments, for example, are graphics processors. The industry has already developed TIGA 2.0, a software interface standard for graphics processor cards.

The Hercules company, which developed the Hercules Graphics Adapter, has created new, intelligent graphics subsystems. The Hercules TIGA card, which is capable of producing up to 16.7 million different colors in one of its operating modes, and its successor, the Hercules Superstation 3D, have been very successful, especially in complex three-dimensional CAD applications.

The Superstation 3D card even combines two graphics processors. A TMS 34020 processor works with the i860 64-bit RISC processor from Intel. This card is equipped with a total of 6 Meg of memory; 2 Meg are used as video RAM and 4 Meg as program memory. All graphics modes supported by this card, even up to a resolution of 1280 x 1024 pixels, are displayed with a vertical frequency of 72 Hz.

Although these cards have amazing capabilities, they are very expensive, especially for a normal PC user. However, these systems were actually designed specifically for professionals. With everyday applications or graphical user interfaces, such as Windows, you'll be able to achieve better results by using more affordable cards.

High color cards

Recently, another generation of relatively affordable graphics cards has captured the PC world's attention. These cards are usually equipped with the popular ET4000 VGA chip by Tseng Labs or with a special accelerator chip for Windows, designated "S3". With 1 Meg of video RAM, these adapters can operate at all VGA resolutions. With the high color operating mode, a total of 32,768 colors can be displayed simultaneously.

However, this color selection is a palette that's permanently defined in the card's BIOS. So the overall palette of "normal" VGA cards, with a total of 262,144 possible colors, was drastically reduced so more colors could be displayed simultaneously. These cards usually have a jumper that allows you to select an "ergonomic mode", in which all VGA resolutions can be displayed at 72 Hz, but with a selection of 256 colors.

8514/A cards

IBM established another graphics standard by developing the 8514/A card. This card is an extension of the VGA standard. It's based on a special graphics controller that the company developed for its own PS/2 series of PCs, which use the microchannel system. The 8514/A graphics card was designed as a type of secondary or additional graphics card, and is installed in systems that already have a standard VGA card.

Subsequent versions of this card, which are able to apply this graphics standard on PC systems with ISA and EISA bus systems, have frequently been faster and better than their original. They have achieved noticeably higher screen redraw frequencies at resolutions of up to 1280 x 1024 pixels. Western Digital, Miro, and ATI have introduced a new generation of 8514/A compatible graphics cards.

The improved performance of the 8514/A controller is especially noticeable under Windows. Because of special video RAM management and video RAM (VRAM) chips, the 8514/A's performance is much better than conventional VGA cards. This improvement enables Windows applications to run up to 60 times faster than before. The ATI Graphics Ultra even has a standard VGA chip in addition to its 8514/A video controller, so it can be operated as the only graphics card in the system.

Other 8514/A compatible adapters, such as the WD8514/A or the Miro Magic, must be connected to the feature connector (a contact strip at the top of many VGA cards) of the existing standard VGA card with a special cable.

There are several ways to increase the performance of your existing VGA card. However, you can do this only if your card is capable of performing at a higher level.

The simplest way to increase the efficiency of your graphics card is to increase its video RAM capacity. However, this isn't possible with every card. Your card must have unused sockets for RAM or VRAM chips so you can plug the new chips into these sockets.

Then you must change a DIP switch setting to inform your VGA BIOS of the increased memory capacity. As we mentioned earlier, more video RAM doesn't automatically mean that your card will be able to handle greater resolutions or provide a larger color

selection. However, in either case, an increased amount of memory will increase your card's speed.

Another way to improve your card's performance is to eliminate or minimize the step effect in diagonal lines and curves. At lower resolutions, diagonal lines and curves appear as steps instead of smooth lines. This occurs because the VGA chip's attribute controller assigns the line color to pixels that are 50% or more covered by the line and the background color to all remaining pixels. This results in a rough color transition.

CEG produces round circles and smooth edges

To solve this problem, you can exchange your digital to analog converter (DAC) chip for a Continuous Edge Graphics (CEG) chip by Edsun Laboratories. This chip can transmit not only pure colors, but also mixed shades, calculated in real-time, in the form of an analog signal. The number of colors stored in the color table is reduced from 256 to 223 to create space for color mixing commands.

This allows a total of 790,000 different colors to be displayed. The color spectrum grows, picture quality is increased, circles become round, edges appear smoother, and color transitions are more natural. However, the contrast level of the resulting picture will be slightly reduced. This chip can be installed only if your VGA card is using one of the following DAC chips: Bt476,ADV476,IMS G171,IMS G176,AV3776,TR9C1710 or GSTGS0276. Also, your current DAC chip must be mounted in a socket; otherwise you'll have to use a soldering iron on your expansion card.

Monitors

The monitor is the most important output device on your PC. In this section we'll take a closer look at how a monitor actually creates its picture. We'll also discuss the differences between various PC monitors.

The picture quality of any monitor depends not only on the technical characteristics of the monitor, but also whether the proper graphics card is being used.

Many dots - one picture

Like television sets, computer monitors consist of plastic housings that contain the required electronic circuitry, the power

transformer, and the picture tube. The picture tube of a monitor works the same way as that of a television set. This tube, which is called a CRT (Cathode Ray Tube), consists of a sealed glass cone with a vacuum on the inside.

The larger end of the cone is flat and rectangular. This is the side that forms the monitor's screen. The other side of the picture tube is narrow and contains cathode plates and small wire grids. When these cathode plates are heated, they produce electron clouds that can move freely within the tube.

The cathodes are then charged negatively while the exterior of the screen is subjected to a positive high voltage charge (about 26000 volts), forming the anode, or positive pole, of the cathode ray tube. The immense voltage difference between the anode and the cathode causes these free electrons to be shot toward the screen.

Permanently installed focusing elements are able to bundle these electrons, so they are focused onto the screen as a beam. This creates an extremely bright dot in the middle of the screen.

However, many of these dots are needed to create a recognizable picture. To do this, four thick coils are placed around the beam. These coils can direct the beam to any location on the screen.

Since the video controller sends a serial picture signal, the information about the individual screen dots is sent sequentially from the upper-left to the bottom-right, row by row. The monitor uses this information to direct the electron beam to the surface of the screen accordingly. Therefore, the beam traces each row across the entire screen, illuminating some dots and leaving others dark. This results in a monitor picture that's composed of countless small dots.

The inside of the screen is coated with a phosphorescent substance that keeps the first dot visible until the last dot is illuminated. The persistence of this coating makes the resulting picture smoother. If the persistence is too long, the picture will be blurry. When the entire picture has been formed, the electron returns to the upper-left corner, sending a new stream of electrons to each relevant dot.

So the beam continually redraws the picture, as long as the monitor is on and is receiving a signal from the graphics card. The

number of times that the electron beam retraces the screen each second is determined by the screen redraw frequency, which is established by the graphics card. Depending on the graphics adapter, this frequency varies from 50 to 70 repetitions per second.

The method above applies to monochrome monitors, since the electron beam always hits one specific pixel, either illuminating it or not. This means that every illuminated pixel has the color of the phosphor on the inside of the screen. Early monochrome monitors used green phosphor and later ones used an amber coating. Today's monochrome monitors almost exclusively have white pictures. A gray scale monitor, which is described below, is a special type of monitor.

Color monitors use a perforated mask

To display a picture in color, the picture signal must be comprised of three components for the primary colors (red, green, and blue). This requires three separate electron beams, one for each of these colors. The phosphorous layer on the inside of the screen is also constructed differently in color monitors.

Coating the screen with three different phosphorous layers (RGB) is a complicated process. These layers are then illuminated through a perforated grid mask. This mask is designed so the electron beam for the red pixels will hit only the red phosphorous layer, and that the beams for the layer hit only the blue phosphor. The holes in the mask have a diameter of less than 0.4 millimeters.

The physical limits of resolution

The center to center distance between these individual holes (dot pitch) determines the number of colored dots that will fit into one screen row. If a monitor displays a resolution of 1024 x 768 colored pixels, which today's VGA color monitors generally do, each row must contain 1024 of these pixels or holes.

The physical length of a screen row is determined by the size of the monitor. A 14-inch diagonal monitor has a horizontal screen width of about 11 inches (28 cm). Most 14-inch monitors are sold with a 0.28 mm dot pitch. This means that a resolution of 1024 x 768 pixels cannot be displayed clearly. However, most monitors supposedly display this resolution.

If you line up 1024 holes 0.28 mm apart, you'll get a row that is 28.67 cm long. However, the screen is only 28 cm wide. Also, monitors don't use the entire height and width of their screen. So, a 14-inch monitor couldn't display this resolution at 0.28 dot pitch. This would be difficult even with a 0.26 dot pitch mask.

However, these monitors usually produce a picture even if the graphics card specifies this resolution. The monitor simply converts the specified resolution to one that it can actually display. In most instances, this doesn't significantly affect the quality of the picture. However, this method won't produce suitable pictures with applications that depend on the precision of your monitor's resolution. A higher resolution simply requires a larger monitor, because a larger area is needed to display more information.

Gray scale monitors often interpret only one color signal

Since gray scale monitors use an analog signal, they are used with VGA cards. These monitors display up to 64 gray scales instead of the usual 256 colors. Usually these monitors receive an analog picture signal for each of the primary colors (red, green, and blue) from the VGA card. Since these monitors are unable to display these three colors, they are equipped with only one cathode cannon and no masks.

Therefore, only one of the three color signals, usually the green component, can be used. Since the signal sent by the graphics adapter is analog, it's possible to display up to 64 different green values through a white phosphorous layer. This results in a picture that displays these green levels as different intensities of white (i.e., gray).

Since this method completely discards the red and blue color signals, pictures that display the red type on a blue background, or vice versa, appear completely black. This occurs because a green component wasn't included. So, with many VGA cards, the card must be configured, through switch settings, for the type of monitor used. Other cards are able to determine whether a color or monochrome monitor is being used. If the adapter is able to recognize the monitor, it will be able to react to these situations and switch to an appropriate monochrome mode.

Horizontal and vertical scanning frequencies and resolution

The vertical scanning frequency specifies the number of times the entire screen is scanned in each second. This value is specified in Hertz. Vertical frequencies of 70 Hz and greater are considered ergonomic or acceptable for long computing sessions. Another factor that affects the quality of the picture is the monitor's resolution. A monitor's maximum vertical scanning frequency is limited by its resolution. The resolution determines the number of lines or rows in the screen mask, and the product of a monitor's number of rows and its vertical scanning frequency is its horizontal scanning frequency.

This is how often the electron beam is required to race from the left side of the screen to the right every second. So, a monitor with a resolution with 480 rows and a vertical scanning frequency of 70 Hz has a horizontal scanning frequency of 480 x 70, or 33600 Hz (33.6 KHz). In this case, the electron beam is required to scan 33600 lines per second. If the resolution is increased to 768 lines, for example, and the vertical frequency remains the same, the horizontal frequency will be 53.7 KHz.

However, most VGA color monitors are designed for a maximum horizontal scanning frequency of 35 KHz. This means that most 14" monitors cannot display higher resolutions at a vertical scanning frequency of 70 Hz. Larger monitors with a 16" or even 20" diagonal are usually built with higher resolutions.

Therefore, they are also inherently designed for much higher horizontal scanning frequencies (up to 80 KHz). This allows them to easily display more ergonomic resolutions, for instance with 1024 lines, at vertical scanning frequencies of 70 Hz and more.

Interlaced mode

We mentioned that the monitor processes the serial signal that it receives from the video controller sequentially or serially. This means that the pixels are illuminated exactly in the order in which the data was sent by the graphics card. Under normal operating conditions the electron beam therefore scans from the upper-left to the lower-right of the screen, illuminating all relevant pixels serially until the entire picture has been lit.

In this way, the three electron beams are direct tools, or slaves, of the video controller. The video controller is the actual conductor;

it determines the sequence, constructing the picture by using the information it retrieves from video RAM.

Any standard VGA color monitor can handle the lower resolution (480 lines) of a VGA adapter at a screen redraw frequency of 70 Hz. It follows all the instructions sent by the video controller. However, as you've seen, this becomes impossible at higher resolutions. So most VGA cards use considerably lower vertical scanning frequencies with higher resolutions. This allows the monitor additional time to scan these extra rows.

However, this method often results in a visible flickering of the picture, particularly when large bright areas are displayed. The interlaced mode is a method that allows the graphics adapter to reduce this flickering to an acceptable level. In this mode, instead of sending all pixels to the monitor sequentially, the video controller skips each second row of the screen. This way the monitor is required to scan only half of the screen pixels in one vertical pass, for example only the even rows.

The next screen redraw then consists of the other half of the screen pixels (i.e., the odd rows). So the video controller alternates between sending two pictures to the monitor. Each of these pictures contains only half of the total screen information. The monitor can easily manage these half-screens, even at 70 Hz, because only half of the rows are being scanned at one time. This is true even if the entire screen contains more rows. This method still results in some flickering. However, this flickering is noticeable only if you use your computer for a long period of time.

As we've seen, many monitors cannot operate at the same speed (vertical scanning frequency) as the video controller. So the video controller is forced to slow down. As a result, most graphics cards are designed to operate either at lower vertical frequencies for higher resolutions, or to switch to interlaced mode.

Unfortunately most cards are built this way; they simply cannot operate at optimum scanning frequencies for higher resolutions. However, there are several graphics cards that are designed to operate in the higher of the three VGA resolutions (480, 600, and 768 rows) at optimal vertical frequencies and in non-interlaced mode. On most of these cards, first you must activate this mode with a switch or jumper on the card's surface. The documentation included with the card contains a warning indicating that using this card with an unsuitable monitor may damage the monitor.

Therefore, the monitor must match the graphics card. First, the monitor must correspond to the graphics standard of the card. For example, an EGA monitor simply won't run on a Hercules card. However, particularly with VGA systems, it's obvious that just any VGA monitor shouldn't be connected to just any VGA card. Of course, this is assuming that you want to use the special abilities and characteristics of the card or monitor.

In this case, you must carefully consider the different types of cards and monitors if you want to avoid subsequent problems. Generally, anything that isn't standardized, such as higher VGA resolutions and VGA monitors, can cause problems. Unfortunately, all the manufacturers are following their own standards.

Multisync monitors

Therefore, Multisync monitors work with various graphics cards. These monitors are capable of synchronizing any video signal within a predetermined range of horizontal scanning frequencies. These monitors are flexible enough to operate on all PC graphics adapters, from the Hercules to the VGA card. This applies if the particular monitor can use horizontal frequencies from 15.6 to 31.5 KHz.

Multisync monitors are usually equipped with an analog/digital switch that allows the monitor to be adapted to both digital and analog graphics cards. Although the designation "Multisync" may be used only by the NEC company, it was still misused. The "NEC 2A" monitor was designated a multisync monitor by NEC, although it's simply an analog multi-frequency monitor.

Since NEC reserved the rights to the multisync name, other manufacturers are forced to call their multisync monitors "multiscan" monitors. This term always refers to monitors that are able to synchronize a range of horizontal scanning frequencies that covers several different graphics standards.

Multi-frequency and fixed-frequency monitors

Unlike fixed-frequency monitors, multi-frequency monitors can synchronize several different horizontal scanning frequencies. Today most VGA color monitors are built as multi-frequency monitors, which enables them to synchronize higher resolutions. Usually these monitors accommodate horizontal frequencies of 31.5 to 35.5 KHz. So the term "analog multifrequency monitor" refers to

monitors that are designed for several different horizontal scanning frequencies and use an analog signal. The only graphics card that uses this type of signal is the VGA.

Usually the different frequencies are recognized by the monitor, which then automatically sets the proper synchronization. Because of this capability, these monitors are also called "autoscan monitors". One particular version of multi-frequency monitor is known as the dual-frequency monitor. This monitor can be connected to a Hercules Graphic Adapter, as well as a CGA card, as a monochrome monitor. The monitor recognizes the type of synchronization it must use.

TTL monitors

TTL (Transistor Transistor Logic) monitors are monochrome monitors that can display only black and white, in some cases with a brightness signal. Although these monitors are driven primarily by Hercules cards, they can also operate on all other MDA compatible graphics cards. However, to do this, these cards must be switched to MDA emulation. TTL monitors use a digital monochrome signal.

TTL RGB monitors

The "TTL RGB" designation refers to digital color monitors that were previously called RGB monitors. Digital color monitors can be driven with either CGA or EGA cards, depending on their horizontal synchronization. A downward compatible VGA card can also be used with this type of monitor, if it's switched to the appropriate emulation mode. The simplest TTL RGB monitors can recognize two signals for each primary color. This means that they are able to either illuminate a pixel of that color or not.

This permits the simultaneous display of up to eight colors. Several models are also capable of recognizing a brightness or intensity signal, so each of these eight colors can be displayed in two brightnesses.

Instead of the intensity signal, expanded RGB monitors (EGA monitors) receive a second state for each primary color. This creates a type of second nuance for each of these colors. This permits the simultaneous display of 16 different colors. These "secondary colors" are generally used by EGA cards.

Video card

In this case, the term "video card" refers to an expansion card that provides a video signal input that permits foreign video images to be processed and/or displayed on the PC's monitor. As you can see from this definition, this topic is rather broad. Although this data format has been a hot topic in the multimedia world for some time now, none of the manufacturers of this type of equipment have developed a standard for operating these devices. So, currently the video card is anything but a standardized component.

We don't want to overlook this interesting area of personal computing, but because this topic is so extensive, we can provide only an overview of these devices.

Common characteristics

Besides being very expensive, all video cards can display a picture that it received from either a camera or a video recorder. These cards are connected to the feature connector of the PC's VGA card with a flat connector cable.

The video picture is usually displayed by using special software under Windows. This software is available for each type of card. So, the software will operate only with the card for which it's specifically designed. These pictures can then be stored in one of several file formats. However, these cards can have very different capabilities and characteristics.

Several video cards are capable of displaying moving pictures on the screen or in a Windows window in real time. So, with these cards you could, for example, display the current TV picture in a corner of your screen while you're working with another application. Other cards can digitize only still pictures, or perhaps display only gray scales instead of color.

The digitalization speed, the number of colors that can be displayed, and the possible resolution are the most important criteria for selecting a video card. However, remember that the range of display methods is limited by the capabilities of your VGA card.

These cards are especially limited in the reproduction of the colors contained in the analog video signal, which is basically an unlimited number. However, this applies only to screen output.

Most cards use a different technique for saving video files. This technique displays many more colors than the VGA card is able to display.

However, some cards actually replace your graphics adapter. So these cards are able to display more than 256 colors. However, other cards can operate in a mode that provides 32,768 colors by using a HIColor card.

Some cards allow their signal to be transmitted to a video system (VCR). This enables you to store video presentations or animation, that you've created with your PC, on video tape. If you're interested in only this type of output, you'll find more affordable alternatives to the usual video card. Usually these devices are connected to your VGA card externally.

A video standard is needed

Unfortunately the lack of multimedia standards for video input has resulted in confusion and high prices. A video interface standard must be implemented eventually. Unless you're in a hurry to equip your PC with a video interface, we suggest waiting until this standard is developed. In a couple of years video processing technology should be available for your PC not only at affordable prices, but also with standardized and user-friendly software.

If you don't want to wait this long, you should ensure that the equipment you want to purchase can actually handle the tasks you want to perform.

Printer

In addition to the monitor and the keyboard, which are essential to PC operation, the printer is the most significant and most widely used peripheral device. The printer enables you to obtain a "hardcopy" or printout of your data or information.

It's difficult to provide an overview of all the available printers because of the various printing methods and the different accessories that are included with printers.

However, all these products have the same purpose: They are designed to print something, that you've created with your PC, on a piece of paper.

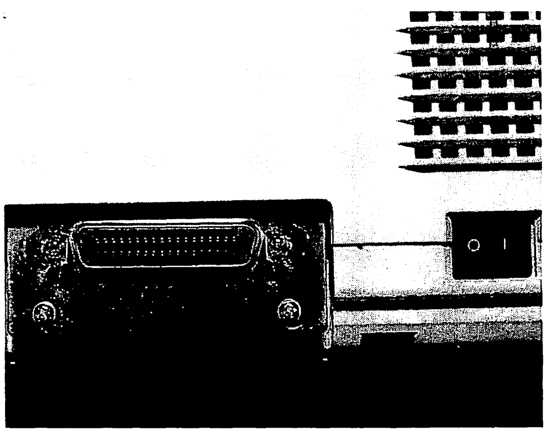
Simple connection

The easiest way to connect a printer to any PC is through its parallel port or interface. Some printers are made to connect to the PC through to a serial port. The printer must use the same type of interface that's used by your PC.

Most printers connect to the computer through the parallel port. A few manufacturers (for example, Apple) don't use this standard. There aren't as many serial printers; we don't know of any printers that are built solely as serial interface printers. However, several different printers have both serial and parallel ports. Also, a serial interface can be added to many other existing printers.

The parallel interface is less expensive and better

We don't recommend purchasing a serial printer. If you want to print graphics, the comparatively low serial data transfer rate will result in long printing times. We also don't recommend adding a serial interface to your existing printer. Instead, you should add a parallel port to your PC.



An example of a parallel interface

Not only does the parallel interface provide higher data transfer rates, it's also more affordable than an additional serial interface for your printer. Usually this interface must be ordered from the manufacturer.

The differences between interfaces are barely noticeable. So, almost all the interfaces will work with your PC. However, there

are many differences between printing methods and other printer features.

Before discussing the advantages and disadvantages of the individual printing methods, we'll discuss the factors that determine the quality of a printer.

Print quality

The final print quality depends on several factors. Often print quality is equal to a printer's resolution. This term refers to the number of dots that can be printed within a certain distance; it's usually specified as a value in DPI (Dots Per Inch). The resolution values that can be achieved by the different printing methods range from 75 to 400 DPI; in special cases even 600 DPI is possible.

Unfortunately the resolution value isn't a reliable way to measure the quality of a graphics printout. Often the specified resolution isn't attainable on paper. For example, a dot-matrix printer may be able to achieve a resolution of 360 DPI. However, the thickness of the pins in its print head may cause the individual dots to overlap, so they can no longer be distinguished. An ink ribbon that is too thick or loaded with ink may have the same effect. It's also impossible for a high-resolution print head to make up for the lack of precision in the printer's drive mechanism.

Density

Another factor that determines printer quality is often overlooked. This is the density (blackness) that can be achieved by a printer. Several printing methods, such as laser printing, are capable of maintaining the same print density, even when the ink or toner supply is dwindling. With other methods, particularly those that use ink ribbons, the print density will decrease noticeably as the ink is slowly used up. This is extremely noticeable on a dot-matrix printer, for example, when you're printing graphics.

Font variety and adding fonts

Each printer has built-in fonts that can also be printed in different sizes. Ironically, the more expensive printers don't provide many fonts. In these instances you must purchase additional font cartridges, which are also expensive, to have the font selection that's standard on many less expensive printers.

With many printers, there is a less expensive way to access additional fonts. This method involves downloading fonts from your PC. Special software "teaches" your printer new characters. There are many shareware products that allow you to download all different types of fonts to dot-matrix, ink jet, and laser printers. However, sometimes to use this software, your printer's memory must be expanded. This isn't always possible, depending on your printer.

Graphical user interfaces, such as Windows or GeoWorks Ensemble, provide another way to access additional fonts for your printer. Instead of using the printer as a text device, these systems create hard copies as pure graphical images.

Unfortunately, these printouts take much longer to print than a normal text hardcopy. However, they do result in a much greater selection of fonts, which are also scaleable. Also, even simple, inexpensive printers, for example 9-pin dot-matrix printers, achieve surprisingly good results.

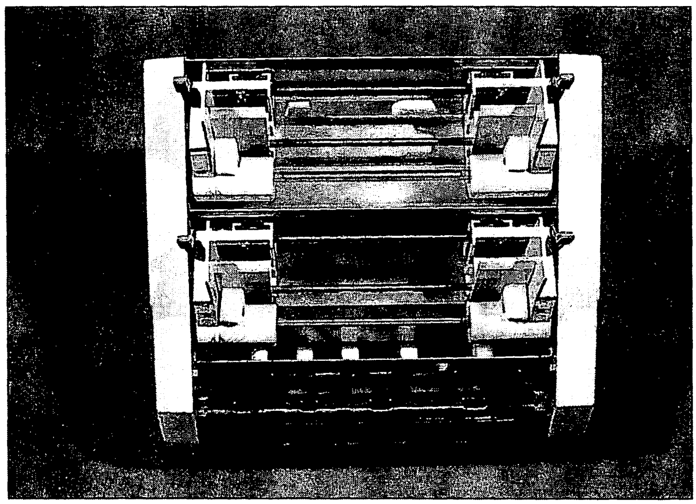
Speed

The printing speeds of different printers vary significantly. Manufacturers tend to exaggerate the printing speeds of their products. A printer's speed is usually specified in either CPS (Characters Per Second) or pages per minute. However, you shouldn't simply accept these values. Manufacturers often list the printing rate for draft quality type, which you probably won't use with your applications. The same printer might take much longer to produce letter-quality or near-letter-quality fonts.

Printing speeds specified in pages per minute, which is common for laser printers and other single-sheet systems, should also be used only as a comparison between different printers. Often manufacturers will calculate this value by printing the same page repeatedly. Although this situation may occasionally occur in actual use, it's not representative of everyday printer use. Printers that will be used in emulation mode may print much more slowly due to the required emulation. Because of this, the printer won't meet the manufacturer's specified printing rate.

Not long ago most printers used continuous feed paper. Many of these printers weren't even able to print on single sheets of paper. Single-sheet printers were expensive and didn't provide a better quality printout than continuous feed printers. The printouts still

looked like they came from a computer printer, so it didn't matter whether the document had perforated edges. However, this is no longer the case.



Single-sheet paper feed

Today's printer technology enables almost every PC user to print correspondence-quality documents. Single-sheet feed systems are available for almost every printer. However, since many PC owners also still use the more affordable continuous paper systems, printers must offer both options.

The paper park function was designed to meet this need. With this function, you can print single sheets without removing the perforated continuous paper. Automatic single-sheet feed systems are also becoming more popular.

These systems use paper cartridges, which load several single sheets into the printer at once. So you don't have to feed each single sheet manually. Some printers have several paper cartridges so you can print on different types of paper without removing the cartridge.

Printer noise levels

Most printers make some kind of noise. Impact printers, such as daisy wheel and dot-matrix printers, are extremely noisy. These printers produce printed images by impacting an ink ribbon on the paper.

However, even non-impact printers make some noise. The actual printing process is almost silent with these printers. However, the ventilation systems of laser printers can be louder than a PC's fan.

The loudest systems are 24-pin dot-matrix printers with poor sound damping. Newer ink jet printers, however, are among the quietest although there are exceptions to every rule.

Printing costs

Printing costs can vary significantly even between identical printer types. For laser printers, for example, the printing cost per page varies as much as 400% between different manufacturers. The cost of ink ribbons and print heads in dot-matrix systems also varies considerably. Thermo-transfer printers are the most expensive. Several extremely compact ink-jet printers are also costly because their ink cartridges last for only several hundred printed pages and are extremely expensive.

Color

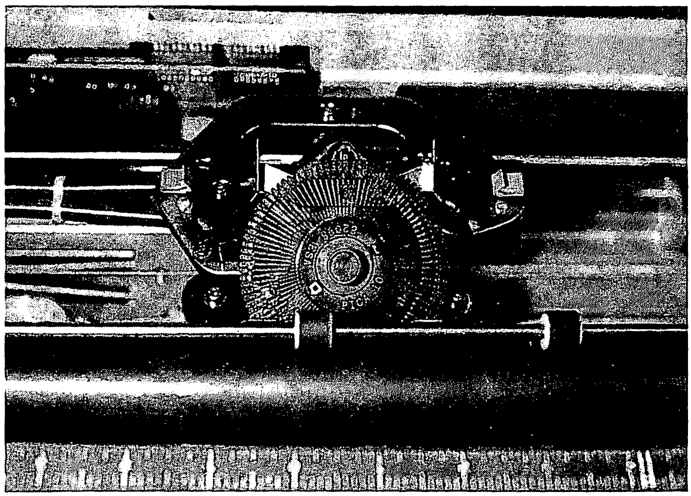
Although color printing technology for PC systems is still in its early stages, several printing methods offer color printing capability at a reasonable price. If you don't have high demands for resolution and the color palette, you may want to consider purchasing a printer with color capability. With several models, especially dot-matrix printers, you can add this capability at a later time.

As you can see, many factors determine the overall quality of a printer. There are also various printing methods, although each technique has its own advantages and disadvantages. In the following sections we'll provide an overview of the different printing methods.

Daisy wheel printers

Daisy wheel printers provide excellent print quality and can produce multiple (carbon) copies. These printers use the same printing principle as daisy wheel typewriters. The 92 characters are located on a small plastic wheel called a printwheel. This wheel must rotate to the correct position before printing a letter. A hammer then drives the character against an inked ribbon so the character is printed on the paper.

These printers can print graphics and different fonts only with a special graphic printwheel. The different graphic patterns are combined to create the graphic symbols. Unfortunately, daisy wheel printers are very slow and print resolution is very poor when using special graphic printwheels.



A daisy wheel

A ball printer works in basically the same way as a daisy wheel printer. This printer uses a type ball, which is a small ball-shaped print head that contains characters on its surface. This ball is rotated to line up the characters. Then, to print a character, the printer strikes the ball against the ribbon.

Both printers have obvious disadvantages. Only the characters that are actually on the print head or the daisy wheel can be printed. So if you want to use more than one font within a single document, you must change the wheel or ball during the printout.

However, only a few word processors have a function that enables you to pause the printout to do this. Special font styles, such as bold or italic type, also cannot be used.

The daisy wheel printers superior quality makes up for their 30-50 character per second (CPS) print speed. However, the noise produced by these printers may be very annoying to you.

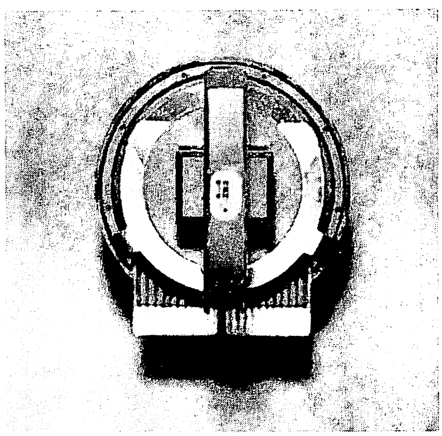
Most daisy wheel or ball head printers use a tractor drive to feed perforated continuous paper that's a standard width. However,

models with single-sheet feed options or wider print rolls are also available.

Dot-matrix printers

Dot-matrix printers are used with almost all PC applications. These printers range from affordable entry-level models, which cost a few hundred dollars, to much more advanced machines, which cost several thousand dollars.

However, all dot-matrix printers use the same printing method. These printers have a head (called a printhead) that has several wires or pins. These pins are driven in different patterns against an inked ribbon. A character is formed when the ribbon strikes a sheet of paper.



A dot-matrix printhead

The printhead is moved horizontally by a stepper motor, either by using a geared belt or another method. This allows the printhead to be moved to any desired horizontal position. In the vertical direction, the paper is moved instead of the printhead.

With perforated continual feed paper, a tractor system is used for this purpose. Single sheets are generally pinched between two rubber rollers, just as a typewriter grabs a sheet of paper.

By combining the horizontal movement of the head and the vertical movement of the paper, it's possible to position the printhead anywhere on the paper. So, with a sufficiently precise drive mechanism, it's theoretically possible to achieve high

resolutions even with only one printing pin. For this reason, most printers have additional needles to speed up the printing process instead of to improve resolution.

24-pin heads

Therefore, the graphics printouts produced by a 9-pin printer, with a resolution of up to 240 DPI aren't necessarily inferior to that of a 24-pin printer, which normally cannot use its maximum resolution of 360 DPI.

However, in printing text, the difference is more noticeable, since each character consists of a matrix of dots. 9-pin printers use 9 dots, or usually just 7 for each character vertically. However, 24-pin printers use 21 or 22 dots, which produces more clearly defined characters.

Some 9-pin printers are also equipped with an NLQ (Near Letter Quality) mode. In this mode, each character is printed a second time with a tiny offset, so the final character actually consists of twice as many dots. Usually the results achieved with the NLQ mode are comparable to the results achieved by 24-pin printers.

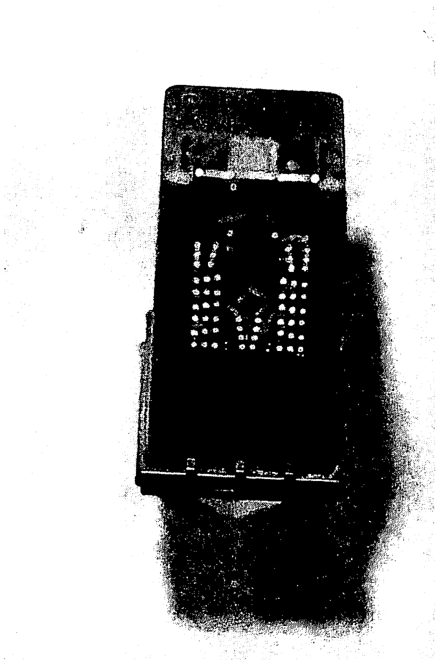
Dot-matrix printers have respectable text printing rates; speeds of more than 400 CPS (Characters Per Second) are quite common. However, remember that you cannot rely on printing rates. Generally a high print quality is more important than a high printing rate.

Only a few manufacturers offer devices that enable their dot-matrix printers to print color. This is surprising considering that such upgrade packages would be inexpensive. With the few printers that do offer this option, you simply must change the ink ribbon and install a special expansion card. This produces high quality color printouts.

Ink jet printers

Ink jet printers are also dot-matrix printers. However, these printers don't use a ribbon. They use a non-impact method to create the printed image. The printhead doesn't even touch the paper. Instead, it sprays a jet of ink in a fine mist onto the paper.

These printers are becoming more popular because of their printing method and falling prices. Another reason why this printer is popular is because it's one of the quietest printers available.



Integrated printhead and ink cartridge

The print method used in ink jet printers is similar to the technique used in dot-matrix printers. The printhead is moved horizontally across the paper by a stepper motor, and the paper is moved vertically either by rollers or a tractor drive.

The ink isn't applied through an ink ribbon, but by the printhead itself. It contains several vertically arranged jet openings through which a special ink is sprayed onto the paper in tiny dots. Two different methods are used to propel the ink from the printhead: The thermal bubble jet method and the piezoelectric method.

The thermal technique uses a small heating element within the jet opening to heat the ink abruptly. A portion of the ink is vaporized, and this bubble of gas then forces the remaining ink out of the jet opening and onto the paper.

Today this technique is so highly refined, this process can occur several thousand times in a single second.

Instead of heating the ink, the piezoelectric method contracts the entire jet opening to blow the ink out of the jet. Because of the piezoelectric effect, certain crystals will contract when subjected to an electrical voltage.

So a piezoelectric crystal is built into each jet opening, which makes it easy to control the expulsion of ink through an electrical ink. Since this method also allows ink jets to be sprayed several thousand times a second, fairly high printing speeds are possible.

Printing rates of about 200 CPS can usually be achieved with both systems, so most ink jet printers can print a single page of text in about 20 seconds.

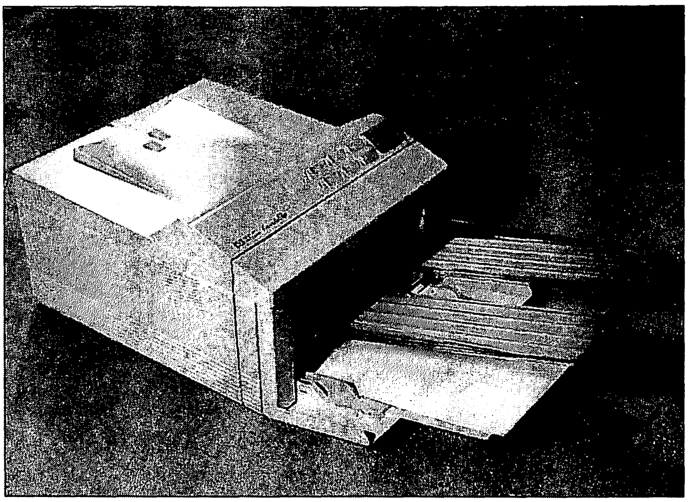
Today both of these methods can attain ink drop sizes, jet diameters and, therefore, also jet-to-jet distances that are small enough so resolutions of more than 300 DPI are possible. In fact, some of the latest inkjets have a 600 x 300 DPI resolution. Unfortunately the actual print quality doesn't quite reach this value. This is because each ink droplet disperses slightly upon hitting the paper, which slightly reduces the sharpness. Although the ink composition has been constantly improved, so it's now even possible to print on normal typewriter paper, this effect still hasn't been completely eliminated. A major advantage of this printing method is that it's fairly easy to use different color ink. Since color ink jet printers are more affordable, high quality multi-color printing is now possible even for the average PC user.

Laser printers

Laser printers use a non-impact method to print. This results in an extremely sharp image at excellent resolutions and high printing speeds. Since the prices of laser printers continue to decrease, many more PC users are purchasing them.

The printing method used in laser printers is similar to the technology used in photocopying machines. Instead of printing line for line, laser printers print page by page. Often laser printer manufacturers will actually use printing mechanisms from photo copiers.

For example, Hewlett Packard laser printers are built exclusively with printing mechanisms that are used in Canon copiers. If you own such a laser printer, you can replace the toner cartridge with one used in a Canon copier.



A Hewlett-Packard laser printer

To print an entire page at a time, the laser printer requires a large amount of memory. The ROM in laser printers creates a full page bitmap of the document. A bitmap is a dot-by-dot representation of each letter or character. The pulses of the laser copy the bitmap.

This laser light is then reflected by a series of mirrors onto a rotating negatively charged photosensitive drum. The laser light scans the drum and changes the printed areas to a neutral charge.

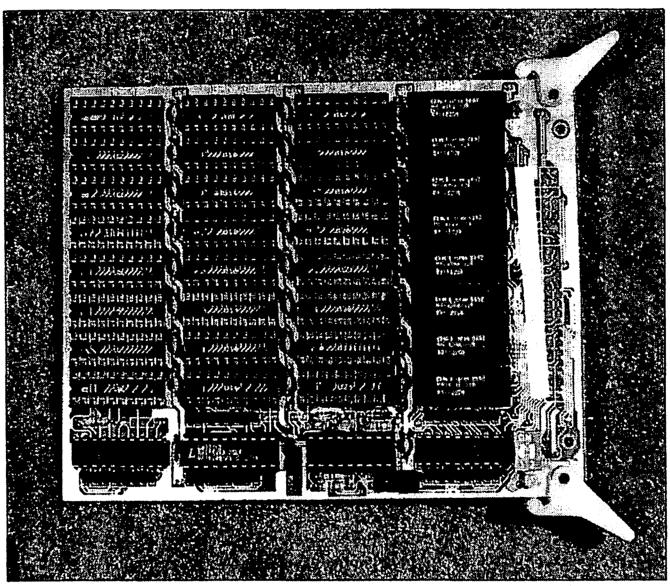
The negatively charged plastic toner powder bond to the neutral areas but not the negative areas. Heat from the rollers fuse the dots of the characters onto the paper.

Resolution vs. memory capacity

So the laser printer also uses a matrix printing system. This system generally achieves a resolution of 300 DPI, and, because of the fineness of the actual printed dots, this resolution is maintained in the final print.

However, graphics printouts reveal the weaknesses of the laser printer system. Before a laser printout is produced, the entire page image must be transmitted to the laser printer (more than a Meg).

The printer must store this mass of data in its entirety before the actual printing can begin. This means that 1 Meg of printer memory isn't sufficient for a full-page high-resolution graphics printout, since the printer operating system also requires a portion of the available memory. Memory expansion up to about 2 Meg are sufficient; higher capacities are generally useful only if a PostScript option is also installed.



A 1 Meg memory expansion for a laser printer

Various accessories and upgrades, such as memory expansions and additional font cartridges, are available for many laser printers.

If you're thinking of purchasing a laser printer, you should consider the price of these items since these vary considerably, depending on the manufacturer. Affordable upgrades are usually available for the expensive laser printers. Also, inexpensive printer memory expansions are also available.

Thermal printers

The thermal transfer method and the thermal reaction method are two printing techniques that are also used.

The thermal reaction method uses the same principle used in FAX machines. This method heats specially coated paper in the places that should be blackened.

Usually thermal reaction printers don't have a movable printhead. Instead, they have a stationary print strip that spans the width of the paper.

This strip contains several separate thermal elements that are used to heat the surface of the paper. So the horizontal resolution of this type of printer, which can print graphics, depends on the number of heating elements, or actually the distance between these elements.

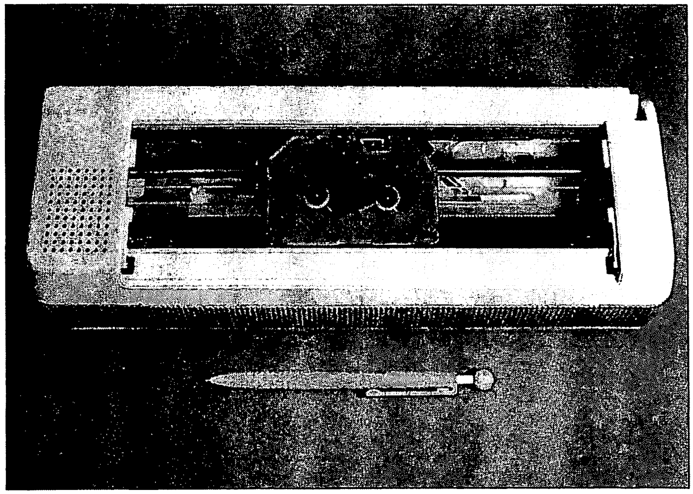
As with so many other methods, the vertical resolution depends on the paper transport. So, theoretically, an extremely high maximum vertical resolution is possible.

The main disadvantage of this system is that special paper must be used. Unfortunately this paper is expensive. Also, since the paper isn't light resistant, high temperatures can cause the print to disappear from the paper. Therefore, this printing method shouldn't be used to print important documents.

The thermal transfer method is similar to the thermal reaction method. However, these printers use ribbons and ordinary computer paper. Although this printing technique is still expensive, it provides a comparatively high quality color printout and is an acceptable alternative to established printing systems, such as dot-matrix or ink jet printers.

Thermal transfer printers use a special ink ribbon that's simultaneously heated and pressed against the paper. This separates the lacquer-like ink layer from the ribbon; the ink then adheres to the surface of the paper. Resolutions of 300 DPI are possible with these types of printers. Even color printouts at 100 DPI, using a raster color screen, are impressive.

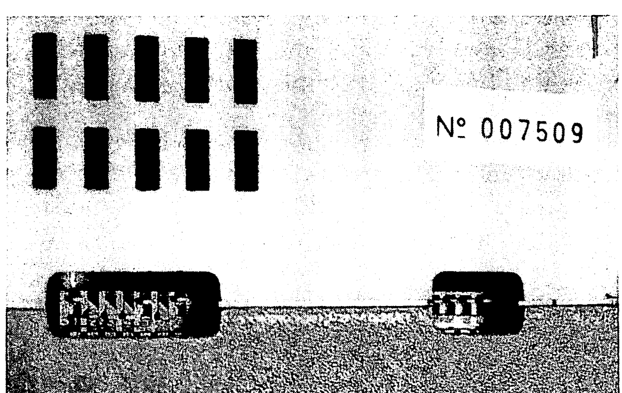
However, these systems aren't very fast. For example, a color graphics printout can easily take several minutes. Also, thermal transfer printers are expensive, especially for color reproduction. So these systems aren't the best choice for most PC users.



A thermal transfer printer

Not long ago thermal transfer printers were marketed with laptop systems. These printers had a movable printhead, similar to that of a dot-matrix printer. However, these systems were never successful and have almost disappeared from the market completely.

Printers, like other parts of the PC system, must be configured. This applies to all the printers previously described. Printers are usually configured through DIP switches or through a configuration menu that can be accessed through switches located on the printer's front panel.



DIP switches on a printer

Character sets

Most printer problems are caused by incorrect printer configurations or incorrectly installed printer software. The most common mistake is an incorrectly set country code.

Unfortunately, printer configuration differs depending on your printer. Normally you must refer to your printer manual. Remember that most systems are shipped with the correct settings. So try to use the printer before making any changes. If you must change a default setting, for example because a function isn't working properly, be sure to write down the original setting.

Plotters

The plotter is a special output device that's normally used for printing graphics and other drawings created on the screen. Plotters draw lines, circles, and other shapes, usually by moving a pen across a large piece of paper.

Plotters create very accurate drawings. Therefore, they are frequently used with CAD (Computer Aided Design) applications. These applications are generally used to create technical and architectural drawings, as well as other vector-oriented (consisting of lines and curves) graphics.

Most plotters include a feature that enables you to switch pens so you can create color graphics and drawings.

Plotters aren't suitable for text output because each character must be drawn individually, which is time-consuming. Also, the characters always look mechanical because it's impossible to vary the line thickness without actually changing plotting pens.

However, in larger formats, where pen thickness isn't as important, plotters can create fairly good pixel graphics by simply drawing numerous individual dots. Actually, plotters can easily handle large format drawings.

How a plotter works

As we mentioned, plotters are designed to draw lines. Straight lines can be precisely defined through their starting and ending points. So the plotter must move its pen, which is usually a wear-resistant felt-tip pen, to the starting position.

Then it lowers the pen to the paper, moves it to the ending position, and then raises the pen again. The plotter can access any specified point on the paper and either lower or raise its pen.

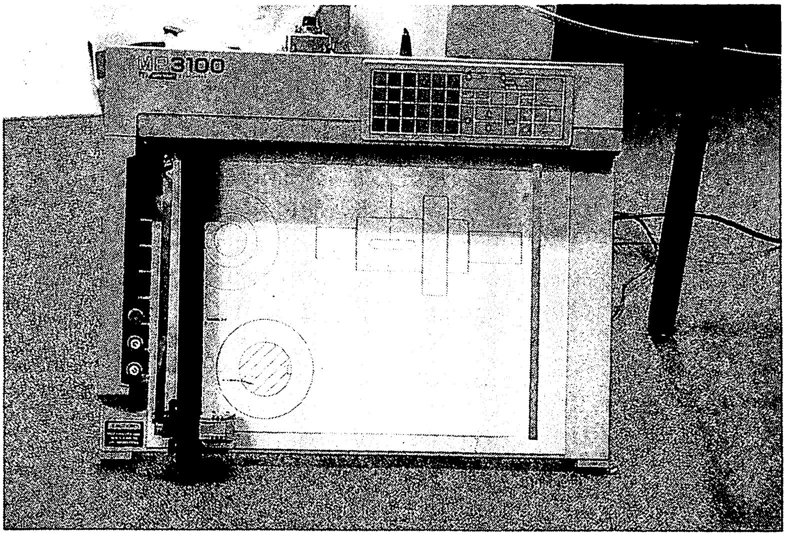
Circles drawn similarly

Circles can actually be drawn in the same way, by repeatedly moving to the ending points that lie on the circle. However, most plotters already have built-in procedures that produce perfect circles, ellipses, and arcs.

In this case, the PC simply must inform the plotter of the circle's center point coordinates and its radius. The plotter does the rest.

Types of plotters

The two popular types are the flat base and drum plotters. Each uses different methods to move the pen over the paper.



An example of possible designs using a plotter

Flat-based plotters

With flat base plotters, the paper is placed completely flat on the plotter's surface. The pen is controlled by a mechanism that's mounted on a type of movable bridge that spans across the paper. Two stepper motors are used to move this bridge across the paper and to move the pen along the length of the bridge. This enables the plotter pen to access any desired set of X/Y coordinates on the paper.

A disadvantage of this setup is that the flat plotter surface takes up a large amount of space, particularly with plotters designed for larger paper formats. So these types of plotters are usually mounted vertically either on a free-standing support or on a wall.

Drum plotters

Space-efficient plotters

With drum plotters, the drawing pen is moved only along a single axis, and the bridge that it travels along is attached to the plotter. To produce movement along the other axis, the paper is moved back and forth beneath the pen.

This is done quickly and as accurately as with flat base plotters. Even when the paper is moved back and forth several hundred times, for example when certain areas of a drawing must be cross-hatched, the image usually doesn't become misaligned, although large distances can be covered by the paper in this process.

Drum plotters are available in various sizes, from standard letter size to legal size. It's easier to use larger formats with drum plotters because the entire sheet of paper doesn't have to lay flat.

Most plotters can use different pens

As we mentioned, most plotters can use different pens. This allows the plotter to create plots using different line thicknesses and/or different colors. Like the actual drawing procedure, the pen selection is controlled through control sequences that are sent by a program (e.g., a CAD program).

So you don't have to insert the pens manually. A plotter should be able to choose from a selection of at least four pens; most models are equipped with six. However, there are also plotters with eight or even twelve different pens.

In most instances the plotter is connected to the PC through a serial port. Due to the relatively slow output speed of plotters and the vector-oriented command set, this transmission method is sufficient. As with other serial devices, it's important to verify that the sending and receiving components are using the same protocol and the same data transmission rate.

For example, consider a Hewlett Packard plotter, such as the 7475A, with a 9600 baud data transmission rate, 8 data bits, 1 stop bit, no parity control, and which must be connected to the second serial port. In this case, you must enter the "MODE COM2 9600,n,8,1,p" DOS command.

The last parameter "p" is important because data transmission is often delayed during a plot while the plotter is executing a complex command. Without this parameter, the data transmission would be halted at such a pause.

Plotter language

As we mentioned, most plotters have a command set that allows complex operations to be accessed through single commands. The Hewlett Packard Graphics Language (HPGL) is the most widely used command set.

Various applications indicate that, with a few exceptions, a program written for the Hewlett Packard plotter usually works with other plotters. So it's important to look for HPGL emulation capability when purchasing a plotter.

Plotting without a plotter

If you have an application program that can produce HPGL files or you have an HPGL file you want to reproduce on paper, but don't own a plotter, you can use a plotter emulator.

These are small programs that can read HPGL files and convert them into pixel-oriented graphics that can then be printed with your dot-matrix printer. These types of programs are also available as shareware and public domain products.

For example, we've used Print GI, which is a shareware program that's available through many sources, such as Computer Solutions. Several graphics programs can also read and process HPGL files. If you have such a program, such as Designer by Micrografix, you may not even need a plotter emulator.

Imagesetters

With imagesetters, text and graphics can be output onto photographic paper. This process is especially useful in the printing industry. However, average PC users can also use imagesetters. Although you'll probably never purchase one of these extremely expensive devices, you may still want to take advantage of the high quality results they provide.

This method of printing is capable of resolutions of up to 4000 DPI. Color graphics can also be printed with amazingly high image

quality. By using an imagesetter to create the image that is subsequently used to produce the film, from which the final reproductions are made, you can obtain the best quality.

You may be able to find a company that let's you use an imagesetter for a fee. If you're planning on doing this, and find several companies that provide this service, thoroughly compare their rates.

You must also ensure that your PC, or rather the application that you're using, is capable of producing a file format that can be processed by the system that's operating the imagesetter.

The PostScript format is usually acceptable since most photographic typesetting shops can work with this format. However, color graphics output is slightly more complicated. So you should determine, in advance, the requirements for outputting color images.

Modems

Modems transfer data between two computers by using telephone lines. FAX signals can also be sent over modems, which are designed to accommodate these functions. Because of this, an increasing number of PC users are using modems.

The data transmission rates of today's modems differ only slightly. Most modems operate at 2400 baud. Higher transfer rates aren't useful because most telephone connections are prone to interference.

Although modems capable of transmission rates of 9600 and even 19200 baud are available, these rates can't actually be used because of the comparatively low transmission quality of the phone lines.

Limited use as a FAX

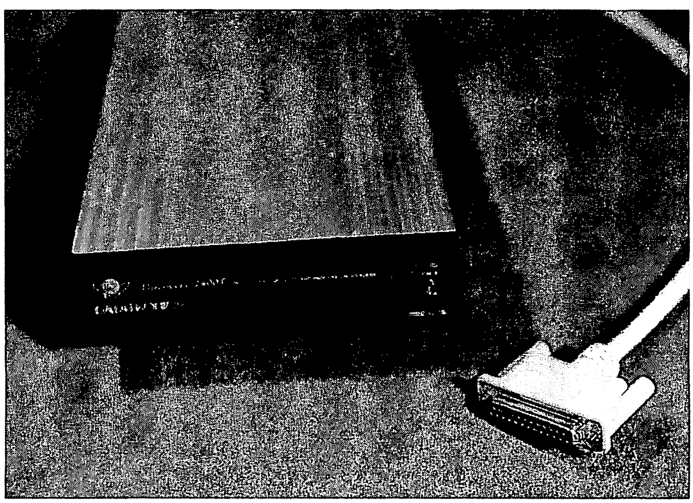
Even a 2400 baud modem can easily use the BTX system through special software. Many modems even include a BTX program. However, if you plan on using your modem for FAX information, you should look for a slightly more powerful model, which also has the corresponding FAX software.

TIP

We recommend using this type of modem only for sending FAX transmissions. If you plan on using the modem to receive FAX transmissions, your modem should be able to receive transmissions even if you're working with a different application on your PC.

External or internal?

When selecting a modem, you must decide between an external and an internal model. The external modem is connected to your PC with a serial cable, also called a modem cable. This modem is then connected to a telephone outlet using another cable. Some models permit you to run a telephone through the modem.



An external modem with its serial connector cable

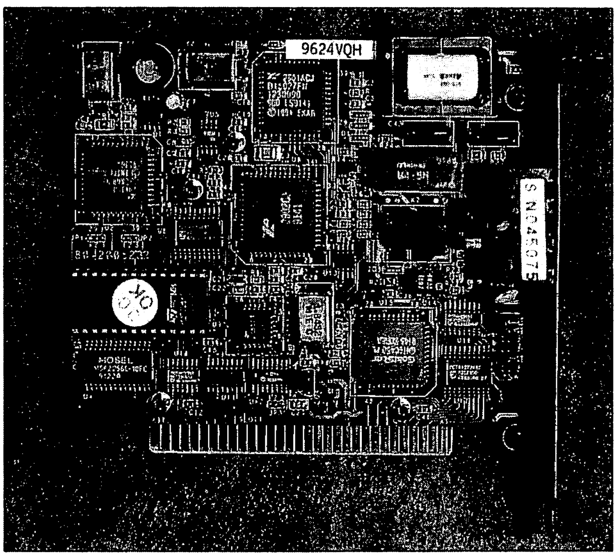
Internal modems are connected to the telephone system in the same way, but they are mounted within the PC case. This requires a free 8-bit expansion slot, in which the modem card is inserted once it's been configured correctly.

This configuration is necessary because internal modems have an integrated serial interface through which they communicate with the PC system. So the installation of an internal modem is identical to the installation of an additional serial port.

Interrupts

As usual, the distribution of interrupts is important. Especially if you're also using a mouse, it's extremely important that the mouse and the modem use different hardware interrupts.

Most newer modem cards can be configured for any of the four COM ports, and generally the interrupt (IRQ3 or IRQ4) can also be freely selected. If your system has only one serial port, it's probably using IRQ4. In this case, you should set your modem to COM2 and IRQ3.



A modem card with built-in speakers

However, if your system already has two serial ports, you can configure your modem to either COM3 or COM4, although IRQ3 should be used in either case. Since this interrupt is actually intended for the fourth serial port, it should actually be used for COM4.

Unfortunately this can lead to problems with older PC systems. In this case, it's possible that only two serial ports can be recognized. Because of this, the only alternative to sacrificing your second serial port is to swap your entire motherboard for a new one. This enables your modem to operate.

Tone or pulse?

Some internal modems have a jumper on the surface of the card labeled "Pulse/Tone". This jumper let's you select either pulse or tone dialing. Most modems are set to tone dialing by the manufacturer. Unless your phone line is set up for pulse dialing exclusively, use the tone setting.

Common problems

The most common problems that occur with modems involve interrupt conflicts, incorrect installation, or incorrect use of the communications software. Usually this software must be set to your type of modem.

If your modem isn't included in the selection offered by the program, you should try all other configuration settings before concluding that something is wrong with your modem.

ISDN cards

ISDN is an acronym for **I**ntegrated **S**ervice **D**igital **N**etwork. This is a worldwide digital communications network. It can be accessed simply by installing an appropriate expansion card in your PC. This makes all the integrated services of the ISDN system, such as telephone, BTX, FAX, and Teletex functions available to your PC.

It also provides direct connections to other PCs and a mode emulation. By using a clever trick, it's even possible to fax and telephone simultaneously by using only one telephone line.

This enormous level of versatility isn't the only advantage of ISDN. Because of its digital data transmission technique, it can reach transmission rates of 64000 BPS, which is a value that's unattainable by any normal modem using an analog line.

If you use the services listed above regularly, you may save a considerable amount of money by installing an ISDN. This is basically because the vastly increased transmission rate will cut phone times drastically.

Software included

Most ISDN cards include special software that's designed to operate with the card and provide the services listed above. Since these programs are usually tailored to specific cards, they usually cannot be expanded or modified. Unfortunately not every card has universal software, so often some options won't be available.

So, you should thoroughly examine any ISDN package before purchasing it. Also, with some functions, such as mode emulations, which permit communication with a mailbox or another PC, for example, you must use a special program. You cannot use a normal terminal or telecommunication program with ISDN systems, because they cannot recognize the ISDN card.

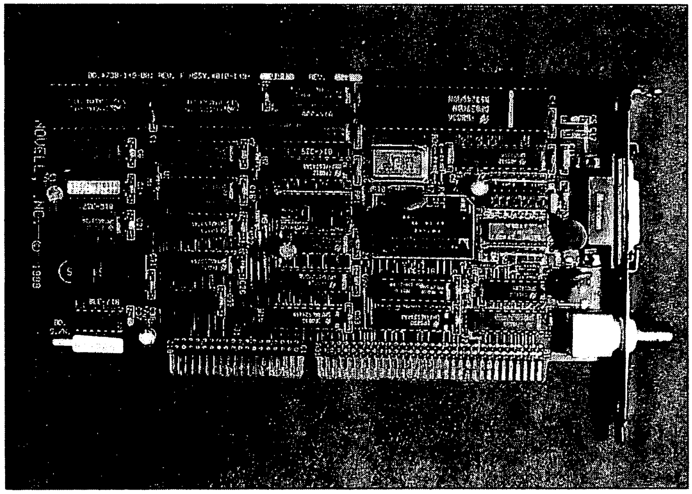
Most ISDN cards include a fairly complete set of installation instructions. None of the cards we've encountered needed to be configured. They are simply inserted into an available expansion slot. The rest of the installation was performed using the software provided with the package, according to the accompanying instructions.

The price of ISDN cards seems disproportionately high when compared with the simple electronics that can be used to operate these cards. Although several high-tech cards are available, their extensive capabilities won't be fully used in most situations.

Even at 64000 BPS, the slowest link in the chain is still the actual transmission line. This makes it impossible to run these cards at their full speeds. However, as ISDN systems become more popular, they may become more affordable.

Network cards

One of the most important features of IBM compatible PCs is the ability to create networks among different systems. PC networks, which consist of only PCs or PCs linked to a mainframe, are becoming more popular. This is happening because of the ever increasing amount of data that must be accessed by various users.



A network card with BNC coupling

It's possible to use a network when several personal computers are located within close proximity of each other. These computers can perform different tasks while using the same software, data files, and perhaps the same printer.

Centralized data storage and decentralized use summarizes the idea behind PC networks. Usually networks consist of a main computer that manages the network and stores programs and data files.

These programs, data files, and any peripherals are used by the entire network. The main PC, also known as the file server, supplies the individual workstations with the needed information and resources on demand. It sends and receives data packages to and from individual workstations via the network connections.

To connect several individual PCs into a network, you must use a special software package that acts as the operating system of the network. Also, a network card must be installed in each PC that's on the network. This card transfers the data packages transmitted over the network connections to the PC's data bus.

These cards are available for all different PC bus widths, from 8, 16, and 32 bits. Various network cards are available. Selecting the proper card depends on the structure of the particular network. Unfortunately we don't have enough space to describe the different types of network cards on the market.

Network card configuration can be complicated

Network cards use a specific address range within the PC's system memory, as well as an interrupt request and a specific port address. With most cards, these settings can be selected through a set of switches or jumpers on the card's surface.

Depending on the other adapters and expansion cards in your system, it can be difficult to configure the network card correctly. Memory address, port address, and interrupt conflicts can cause problems.

Besides these basic considerations, there really isn't anything you can do to increase the performance of a network card. If the connections between the PCs in the network are working flawlessly, you've done everything there is to do.

CHAPTER

3 Operating Systems

You're probably wondering why we're discussing operating systems in a book about PC hardware. After all, operating systems are basically software. However, the operating system is vital to the hardware of the PC system. So, in this chapter we'll briefly discuss the MS-DOS, Microsoft Windows, OS/2, and UNIX operating systems. However, we won't discuss individual DOS commands or try to teach you how to use Windows.

Hardware must be managed

The operation and especially the effectiveness of the hardware in any PC system is linked with its operating system. The best and fastest microprocessor is useless if your operating system cannot use its functions. Also, certain limitations of the operating system might make memory expansions or the addition of a larger hard drive completely useless.

However, the efficiency of a PC system also depends on the optimal configuration of its operating system. Often it's possible to solve problems by changing the system configuration instead of spending lots of money on new hardware components.

We'll illustrate the connections between your system's hardware and its operating system by presenting an overview of the various functions performed by this important software.

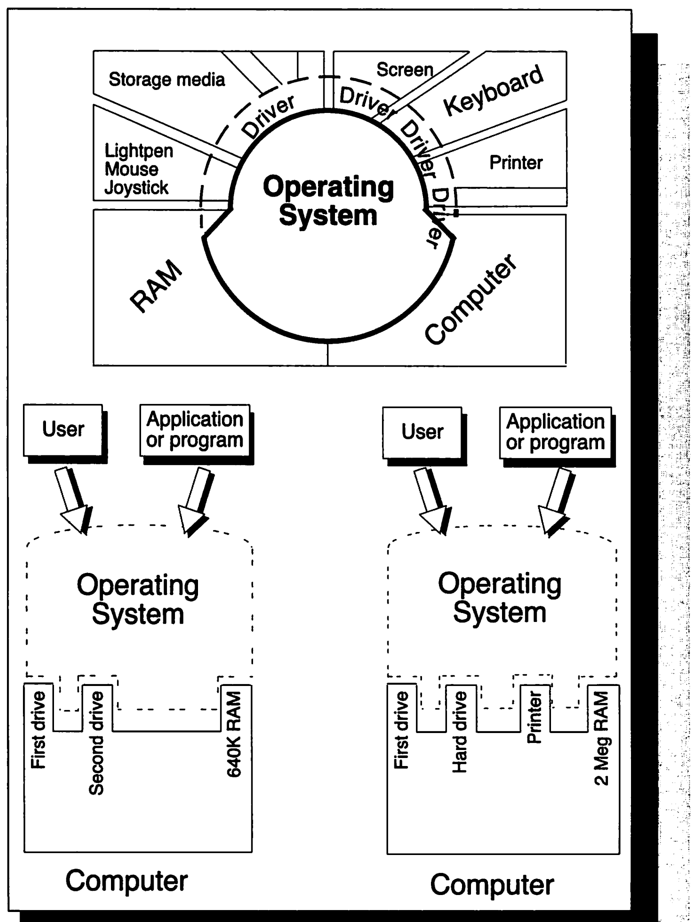
Operating system tasks

Perhaps you've already discovered how important the operating system is to the operation of your PC system. If for some reason the operating system cannot be loaded or cannot run, you won't be able to use your computer. Functions cannot be executed and programs cannot be loaded.

Operating system's main task

The operating system handles standard functions

The operating system's main task is to provide the functions required to operate the PC system. So, the operating system is a connection between your system's hardware and its application programs. This makes it possible for different programs to access a uniform structure. This is especially important for hardware components because they can vary significantly, depending on their manufacturer or processor architecture.



Main tasks of an operating system

Also, without an operating system, each application program must provide its own file management system or disk drive routines in addition to its intended function.

All operating systems must also provide several utility programs supporting the general use of the PC system. For example, a program for formatting data carriers is essential; most operating systems have this standard function.

However, an extremely powerful and user-friendly file manager, which would support common file management tasks, such as copying, moving, or deleting files, is more difficult to find.

Compatibility vs. flexibility

The standardization of hardware functions is the biggest problem in the development of different operating systems. As an operating system ages, it's more difficult for the system to accommodate updated hardware components, such as advanced processors, without discarding an established standard.

Obviously manufacturers aren't eager to do this because existing or older applications will then no longer be compatible with the revised operating system.

This is the main reason why there hasn't been much development in PC operating systems even though hardware technology is constantly evolving. Only recently has this situation changed.

Finally PC users can choose from a larger selection of operating systems. All these systems try to remain compatible with existing software, although they do this in various ways.

In the following sections we'll discuss the most common operating systems. We'll also discuss how these systems may be improved in the future.

3.1 DOS

DOS is an abbreviation for Disk Operating System. As its name indicates, DOS was originally designed to load the operating system from a floppy diskette. When PC technology was just beginning, most PC systems didn't have hard drives.

As the first IBM PC was introduced to the world in 1981, the software company Microsoft simultaneously presented its brand new MS-DOS (or PC-DOS) operating system. It was designed for the Intel 8086 or 8088 processor, and was perfectly suitable for the standards of the day.

Hard drives and directories developed in 1983

With the development of the IBM XT, which had an integrated hard drive, Microsoft introduced Version 2.0 of MS-DOS. This version supported the operation of hard drives and, inspired by the UNIX system, allowed files to be organized in individual directories and subdirectories.

MS-DOS 2.0, as well as Version 2.11, which was released shortly afterwards, permitted a maximum hard drive capacity of 32 Meg. At the time, this was considered a lot of disk space.

Version 3.3

Version 3.0 was also released as a response to contemporary hardware developments. The IBM AT needed an operating system that would support its 1.2 Meg floppy drives and the larger drives that would soon be developed.

When these larger drives appeared, Version 3.3 of MS-DOS was released. This operating system could divide a hard drive into several partitions, which were identified by their own logical drive letters. However, each partition was limited to a capacity of 32 Meg.

Starting with this version, MS-DOS also supported the use of 1.4 Meg floppy disk drives. MS-DOS 3.3 proved itself to be a very reliable and flexible operating system that was able to meet most demands. Even today some PC systems are still running this version of DOS.

Competition from "Doctor DOS"

Microsoft's success with DOS prompted competition from Digital Research, which developed the older CP/M operating system. Digital Research introduced its MS-DOS 3.3 compatible operating system called DR DOS. Not only was Version 3.41 of this operating system slightly more affordable than its Microsoft counterpart, it also supported hard drive partitions of over 32 Meg.

Better equipped

Since its introduction, DR DOS has established itself as an indispensable operating system by initiating many improvements and developments. One important development was the addition of utility programs to operating systems.

Version 6.0, in particular, has some excellent features, such as a data compression program to increase hard drive capacity and a password feature to protect certain files from unauthorized access.

However, although many DR DOS users think that it is an excellent operating system with useful features, others aren't satisfied with its performance. Many of these users quickly switch back to MS-DOS.

MS-DOS Version 4.0

Version 4.0 of MS-DOS, introduced just shortly after the release of Version 3.0, could manage hard drive partitions of over 32 Meg, just like its competitor, DR DOS 3.41. It was also the first MS-DOS version to include a fairly elaborate file manager, called DOSSHELL. This file manager lets users select standard file management functions from a menu. However, the DOS prompt was still the basis of DOS operations.

Because of some bugs in MS-DOS 4.0, many users switched back to MS-DOS 3.3. MS-DOS 4.1, which was introduced one year after the introduction of Version 4.0, was a corrected version of its predecessor. However, it was also noticeably larger than the older Version 3.3. Because of this, Version 3.3 was still widely used in PC systems.

Version 5.0: A new standard?

With the introduction of MS-DOS Version 5.0, Microsoft again offers an excellent operating system. Before releasing this version, Microsoft thoroughly tested it. This version also offers several desirable developments, such as improved memory management and a task switching capability, which lets the user switch between two different DOS applications.

However, this task switching capability isn't true multitasking. DOS temporarily places one of the two running applications in the background. This version's improved use of memory permits certain portions of the operating system to be loaded into high memory, which makes more conventional memory available to application programs.

However, even with this feature, a maximum of 627K of conventional memory are accessible by these programs. We'll discuss this problem in more detail later.

Memory dilemma

The biggest advantage of all disk operating systems is that they are downwardly compatible. However, this also enables all existing DOS applications to operate with the current version of DOS, which creates an enormous selection of software.

Unfortunately this software is forced to operate in a mode based on the 8088 CPU, which was introduced in 1981 with the IBM PC. This computer had a maximum addressable memory range of 1 Meg, which was pretty impressive when you consider that the first PC had only 64K of memory.

As you know, hardware has developed rapidly since this time. Even the 80286 was capable of true multitasking and of addressing 16 Meg of RAM. However, to do this, it must operate in Protected mode. DOS cannot use this mode.

All addresses are already occupied

MS-DOS has a completely predetermined and unchangeable memory structure which limits the memory available to application programs to the address range 0000 to A000, a memory capacity of 640K. Addresses A000 to FFFF, corresponding to another 384K, are reserved for system functions, such as the hardware BIOS or video RAM.

Because of the 8088 compatibility, these are the only available addresses. The operating system is also loaded into this 640K memory range, so the amount of memory that's actually available to DOS programs is even smaller.

Version 5.0 of MS-DOS permits the core of the operating system and device drivers to be loaded into a high memory area. So only a minimal portion of the operating system must be placed within conventional memory. This makes a maximum of 627K of conventional memory available to application programs.

Tips for installing MS-DOS 5.0

Strange default settings

An automated installation procedure copies MS-DOS from the original diskettes to your hard drive. The installation procedure creates AUTOEXEC.BAT and CONFIG.SYS files with simple default settings that don't fully use the capabilities of the operating system, and can even lead to problems in its operation. With the EDIT CONFIG.SYS command, it's easy to use your DOS editor to make several changes that will improve these settings.

A universal CONFIG.SYS file for DOS 5.0 might look something like this:

```
DEVICE  = C:\DOS\HIMEM.SYS
DOS     = HIGH, UMB
BUFFERS = 40
FILES   = 30
COUNTRY = 49,,C:\DOS\COUNTRY.SYS
```

We don't recommend changing any of the other settings made by the installation program. For example, using the MODE CON command to set certain code pages can lead to problems, especially with displaying the correct characters on your screen.

Refer to your DOS 5.0 manual for more information about the best configuration for your system.

Why a new MS-DOS 6.X?

Since MS-DOS 5.0 was clearly an important improvement over other DOS versions you're probably wondering whether a new version of MS-DOS is needed, especially with the existence of Windows and OS/2.

However, Microsoft believes updating DOS is important. A major reason Microsoft continues to develop MS-DOS is that DOS is the operating standard for the PC. So, when this standard is improved, millions of PC users benefit. Also, Windows is still an operating system add-on that relies on the basic functions of MS-DOS. So, increasing MS-DOS's performance also increases the performance of Windows.

MS-DOS 6.X in brief

Before presenting the new features of MS-DOS 6.X in detail, we want to give you a quick overview:

- MS-DOS works even more closely with Windows. Certain drivers have been optimized and important programs are included in both MS-DOS and Windows versions.

- MS-DOS 6.X has a powerful help system that lets you search for and print out information.

- MS-DOS 6.X offers improved data security, with programs for virus detection, backups and recovery of deleted files. Since these collaborate closely with the other MS-DOS functions and are also available as Windows versions, they will quickly evolve into a standard.

- MS-DOS can effectively double your valuable hard drive space by automatically compressing data.

- MS-DOS 6.X includes a defragmentation program to reorganize your hard drive, where files tend to become scattered and fragmented over time. Defragmenting can speed up hard drive access and allow larger permanent swap files for Windows.

- MS-DOS 6.X can automatically optimize main memory with MEMMAKER. Better drivers for extended memory also make more memory available for MS-DOS and Windows.

- A new hard drive cache (SMARTDRV.EXE) offers improved performance with Windows and compressed hard drives.

- MS-DOS 6.X offers flexibility in the AUTOEXEC.BAT and CONFIG.SYS files, as well as the option to ignore bad system files for "emergency" starting.

All improvements and extensions preserve maximum compatibility to existing versions of MS-DOS and DOS programs. According to Microsoft, MS-DOS 6 is 100% compatible with previous versions.

MS-DOS and Windows

MS-DOS 6.X improves upon the already impressive collaboration between MS-DOS 5.0 and Windows 3.1. In some respects, MS-DOS and Windows are so well dovetailed that using a "different" operating system or interface may severely impair performance.

Better memory management

MS-DOS 6.X improves the allocation of available memory, leaving more memory free for application programs. These improvements are carefully tuned to Windows memory requirements, so both program packages profit from them with neither one encroaching on the other.

For many users who were formerly not managing options and parameters to the best advantage, the available memory will increase drastically with MS-DOS 6.X. The new version includes a powerful utility called MEMMAKER that handles memory optimization automatically.

Workgroup Client

If your computer has a network card installed, it can easily be connected to one or more Windows for Workgroups computers, Windows NT computers or a LAN Manager Server.

You then have easy access (controllable by passwords) to the hard drives and directories of Windows for Workgroups computers. Access control can also be exercised from other programs via a memory-resident pop-up program.

Using a network printer in a Windows for Workgroups network is equally easy. This not only solves many problems associated with printing to different printers, but also saves the cost of purchasing additional printers or complicated printer switches.

Windows backup programs included for data security

MS-DOS 6.X includes a robust assortment of programs for ensuring data security. Most have already proven their worth as popular products of well-known utilities developers.

One great advantage of the data security features is that the same programs work in both DOS and Windows. This way, a hard drive backed up from Windows can be restored from within DOS. Program operations and interfaces are also the same when scanning for viruses and recovering deleted files.

The only difference is that the Windows programs use the Windows display capabilities, while the DOS programs use the SAA interface.

Windows-compatible hard drive compression

A hard drive compression program is of little value unless it is 100% safe and works well with Windows. The MS-DOS 6.X "hard drive doubler" works with Microsoft's MRCI (Microsoft Realtime Compression Interface). This means that the compression technique

is thoroughly integrated and will not interfere with any DOS commands or Windows processing.

Windows-compatible cache program

The cache program SMARTDRV is also designed for seamless integration with Windows. SMARTDRV can cache hard drives and diskette drives, including disk write accesses. As a result, drastic increases in access speed can be achieved.

SMARTDRV can also lend memory to Windows to help alleviate bottlenecks. A special Windows application called SMARTMON lets you monitor the caching process. You can use the information thus obtained to optimize cache settings.

Choice of system configuration

Another useful feature for working with Windows is the ability to add menus and options to the AUTOEXEC.BAT and CONFIG.SYS system files. This is good news for users who previously had to get along with compromises in system file settings, or who used different variants for DOS and Windows and copied them over as needed. Now you can choose from multiple configurations in the MS-DOS start phase.

This makes it easy to use the optimal configuration for MS-DOS or Windows according to your needs.

Convenient data security

Protecting valuable data is increasingly vital to PC users. MS-DOS 6 offers clear advances in data security, as seen in the following areas:

Computer virus protection

MS-DOS 6.X offers effective protection against computer viruses through an anti-virus program for MS-DOS and Windows. Besides checking both hard drives and diskettes for stored viruses, the program also scans memory to provide active protection against any viruses and their attempts at destruction.

Powerful backup

Backing up your hard drive is fast and easy with MS-DOS 6. The Windows variant of the backup program can even run as a

background application. Users with little or no experience can expect to perform trouble-free backups with ease.

The use of special hardware capabilities makes the backup program very fast, and the number of diskettes required is considerably reduced by data compression techniques.

Easy file recovery with Undelete

Already in MS-DOS 5.0, a program was available for the recovery of deleted files. The program, however, required a good working knowledge of DOS and could not be run from within Windows. In MS-DOS 6.X, Undelete is more powerful and easier to use. Files are actually stored in a hidden directory for a time rather than immediately deleted. This provides better protection against accidental data loss, especially with network drives. The Windows version of Undelete also lets you restore files from within Windows.

Improved hard drive usage

Along with data security, great value is placed on the efficient utilization of hard drive space. MS-DOS 6.X offers several aids for efficient disk usage:

DoubleSpace

Despite constantly increasing hard drive capacities, program requirements for disk space seem to increase even faster. For this reason, finding enough disk space continues to be a concern for many users. MS-DOS 6 includes a special program that effectively doubles the storage capacity of an existing hard drive. In most cases, the compression technique that accomplishes this is barely noticeable to the user. Whether or not there is an impact on overall performance depends mostly on the speed of the drive itself. For slower disk drives, compression coupled with caching and defragmentation (see below) can actually improve access time.

Microsoft is likely to set a standard with its integrated compression software DoubleSpace. The danger of compatibility problems or data loss is then drastically reduced compared to compression programs of other developers. The compression program is very user friendly, requires no special procedures to use, and can also compress diskettes and removable hard drives. Installation is so safe that, if interrupted by a power loss, the procedure can simply be restarted and will continue without

problems. The program can also recognize disks that have been compressed by Stacker. Optimal compatibility with Windows, the MS-DOS 6 defragmenter DEFRAG and the cache program SMARTDRV is guaranteed.

SMARTDRV

MS-DOS 5.0 included the cache program SMARTDRV to speed up access on slower hard drives. In MS-DOS 6.X, this program is considerably more powerful and user friendly. MS-DOS automatically sets up the program during installation and also enables caching for write accesses, clearly enhancing overall performance. When SMARTDRV is used in conjunction with DoubleSpace, the improvement is even greater, since compression permits greater quantities of data to be cached. Also, SMARTDRV works smartly with Windows. It can lend space to Windows, and a utility called SMARTMON can be used from within Windows to monitor and control SMARTDRV.

DEFRAG

A disk tends to become fragmented with repeated use. As files are created, changed and deleted, gaps develop in the data, so instead of covering a contiguous area it is scattered in disconnected pieces. This requires more frequent disk access and can slow performance considerably. MS-DOS 6.X has a utility called DEFRAG that can restore order to your disk. Unlike similar utilities from other vendors, DEFRAG is integrated by MS-DOS 6 to work trouble-free with SMARTDRV and DoubleSpace and can even support and enhance their performance.

Memory optimization

Version 5.0 of MS-DOS brought significant improvements in memory availability. Many computers that previously had 450K - 520K free for application programs could increase this to 580K - 610K under MS-DOS 6.

MEMMAKER

Unfortunately, taking advantage of these improvements was not always easy. Many users were reluctant to use the available techniques because of their intricate nature and the complicated control parameters required to implement them. Some mistakes

could even hang the system and make it impossible to restart the computer.

In MS-DOS 6.X a special utility called MEMMAKER makes memory management safe and easy. You no longer have to worry about disabling your computer by choosing the wrong settings. MS-DOS 6.X uses more special resources for memory management and can be optimized explicitly for Windows. Complete compatibility with all MS-DOS programs that use high or extended memory can be expected.

Improved EMM386

The EMM386.EXE memory manager has been improved and expanded. It gives more high memory to TSR programs and device drivers and can manage both extended and expanded memory in a single pool, eliminating the need for prechecking of memory type. The result is more available memory for application programs.

Memory management information

The user has better access to the details of memory management. MS-DOS 6.X includes a special diagnostic program called MSD(MicroSoft Diagnostic), that provides information about particular regions of memory and device drivers. The MS-DOS command MEM also has additional options that extend the amount of information available to the user.

Improved operating system functions

Besides the many enhancements to the user interface and typical user tasks, MS-DOS 6.X offers notable improvements for the system manager and advanced DOS user as well.

Safer installation

Installation of MS-DOS 6.X is so safe that you can even restart your computer during installation and then continue the process or restore the system to its former status. The same is true for conversion of Stacker-compressed drives.

The installation process addresses all the major system components. Optimal settings are generated for available memory, and disk compression and caching can be implemented with flexibility and ease. MS-DOS 6.X network extension, available

from Microsoft, simplifies network (Windows for Workgroups, Windows NT, or LAN Manager) connection by automatically recognizing an existing network card and performing the appropriate setup. An installed OS/2 will also be recognized and taken into consideration.

Variable boot options

MS-DOS 6.X makes it possible to include flexible configurations for booting in the system files AUTOEXEC.BAT and CONFIG.SYS. Then depending on your particular purpose, you can specify which configuration should be used for startup.

Safer starting

Many users had major problems after modifying their systems because the AUTOEXEC.BAT or CONFIG.SYS files were improperly changed. Such problems could even prevent the computer from starting.

MS-DOS 6 provides the ability to perform an "emergency" boot by ignoring both of these system files. Press the key. Alternatively, you can request an interactive mode in which you confirm or skip the commands in the system files line by line.

Complete on-line documentation

Besides the help previously available for individual commands, MS-DOS 6.X includes a free-standing utility that provides menu-controlled documentation on all MS-DOS commands, complete with examples of their use. The documentation can also be printed.

INTERLNK for desktops and laptops

Even without special network hardware, MS-DOS 6.X permits easy data exchange between two PCs with a null-modem cable. This feature is of interest primarily to laptop or notebook users, who frequently need to exchange or update data with a second computer.

Disk scanning and repair

MS-DOS 6.2 presents ScanDisk, a utility for scanning disks for errors, and making the errors so DOS avoids them.

The future of DOS

It's difficult to determine the future of DOS. Considering the continuing trend of hardware development and the ever-increasing demands that software applications are placing on operating systems, DOS's future doesn't look promising.

Any new operating systems will most likely be DOS compatible. This will ensure that users can run their existing DOS applications, at least until the new standard is well-established and acknowledged by software manufacturers.

IBM has already taken a big step in this direction with the OS/2 2.1 operating system. Whether Microsoft is successful with its newly-released Windows NT and upcoming Windows 95 (Chicago) remains to be seen. As long as the leading manufacturers provide for existing DOS applications, you don't have to decide on one operating system.

3.2 Microsoft Windows

Technically, Microsoft Windows is an extension of DOS instead of an actual operating system, at least in is current 3.1 version. Therefore, it isn't loaded when the system is booted. Instead it's started with the WIN command from the DOS prompt. However, once Windows is started, it behaves like an operating system.

Windows history

Windows was introduced in 1985. However, even Version 2.0, which was released in 1987, was never able to establish itself firmly on the PC market even though it offered the advantages of a graphical user interface. The real breakthrough came with Version 3.0, which promised a way to avoid the infamous 640K memory limit. This would enable users to fully use the capabilities of 286 and 386 systems.

Although a version of OS/2, which had similar capabilities, was already available, Windows was successful. This was mainly because of lower hardware prices and the lower price of Windows itself, which made it more accessible to average PC users.

Windows operating modes

The primary advantage of Windows is its ability to actually use the different operating modes of 286 and 386 processors. As we mentioned, MS-DOS cannot do this. Windows has different sets of hardware requirements in its various operating modes, which also results in different performance levels.

Real mode

Older applications operate in Real mode

This operating mode corresponds to that of MS-DOS. It's completely XT compatible. The addressable memory range is limited to 640K, although it can be enlarged using expanded memory (EMS). Version 3.1 of Windows no longer uses this operating mode.

Minimum hardware needed to use Real mode

- Processor: 8086/8088 • Memory: 640K

Characteristics

Completely unsatisfactory performance on XT systems; Windows Version 3.1 cannot run on these PCs anyway. Older Windows applications that use this mode must use Version 3.0. To start Windows in Real mode, load it with the /r switch.

Standard mode

Full use of RAM

This operating mode fully uses the Protected mode of 286 and higher processors. It's possible to address 16 Meg of RAM directly. This means you can avoid the old 640K memory limit and finally use the system's entire extended memory.

Virtual mode, with an addressable memory range of 1 gigabyte, is also supported. This makes it possible to run memory-intensive programs even with smaller RAM capacities by temporarily storing data on the hard drive.

However, since this requires the hard drive to be accessed very frequently, program execution is slowed down considerably.

Minimum hardware needed to use Standard mode

- Processor: 80286 • Memory: 1 Meg

Characteristics

Since operating Windows in Standard mode requires at least 1 Meg of RAM, ATs with only 640K of memory must operate in Real mode. Therefore, Version 3.1 cannot be installed on these systems. On 386 systems, Windows can be started in Standard mode by activating it with the /s switch.

Enhanced mode

Virtual PCs

This is the most powerful Windows operating mode. With Enhanced mode you can operate your PC in the virtual mode, which allows true hardware multitasking. So your PC can act like several separate DOS PCs, all working on their own applications. You can switch between these different DOS tasks as needed.

Minimum hardware needed to use Enhanced mode

- Processor: 80386SX
- Memory: 2 Meg

Characteristics

Enhanced mode increases performance only if your system has a large amount of RAM. If you have less than 4 Meg of RAM and don't need the capabilities of Enhanced mode, you should use Standard mode.

To activate Enhanced mode, use the /3 switch when starting Windows. By starting Windows in this way, it's also possible to operate in Enhanced mode with only 1 Meg of RAM, although this isn't necessarily efficient or desirable.

More PC performance, more Windows performance

Unfortunately, the advantages offered by Windows come with a price. Although Windows uses the capabilities of newer processors, many of these resources are actually used to run Windows.

So a standard application, such as a word processor, may actually run more slowly under Windows than under DOS. This can occur even if the processor is operating in a more efficient mode.

To use Windows efficiently, many demands are placed on the system's hardware components. So the amount of memory your PC

has, and the hard drive seek time, affect the overall performance of the Windows environment.

Therefore, you should consider several factors when configuring Windows. Occasionally, just a few simple changes can lead to noticeable increases in performance, without requiring expensive hardware upgrades or expansions.

We'll discuss some of the most important factors that affect Windows' performance. For more information, refer to your Windows documentation.

Installing a permanent swapfile

Using a permanent swapfile makes it much easier for Windows to store information on the hard drive temporarily. This increases Windows' speed. Version 3.1 of Windows automatically creates a swapfile when it's installed on your hard drive.

With Version 3.0, you can create the file after Windows has been installed. To do this, first start Windows in Real mode by using the /r switch, then run SWAPFILE from within the File Manager.

A dialog box, in which Windows displays the default size of the swapfile that will be created, appears. You should use the default value, unless you have a limited amount of available hard drive space. In this case, you should enter a smaller value because the disk space occupied by the swapfile cannot be used by other applications.

Defragmentation

To create a swapfile, Windows needs a contiguous segment of hard drive space. So you should defragment your hard drive using a utility such as the BeckerTools Disk Optimizer, if you have a program that will do this, before actually calling SWAPFILE. It's important to defragment your hard drive regularly to keep Windows running efficiently.

Windows 3.1 upgrade

If you have an early version of Windows, we recommend upgrading to Version 3.1. In addition to improved performance, you'll also receive a more highly developed and reliable product that's equipped with several useful additions. Improvements, such as the completely reconstructed File Manager, make this a worthwhile investment.

Correct path?

The first path is usually correct

This is a simple test that can be done quickly. The PATH statement in your AUTOEXEC.BAT file should contain your Windows directory as its first entry, similar to the following statement:

```
PATH = C:\WINDOWS;C:\DOS;C:\TOOLS
```

The Windows SETUP program automatically places this entry in the correct location. However, if you installed subsequent programs, your PATH statement may have been modified and other directories may have been inserted before the Windows directory.

If this occurred, you can shorten access times to Windows files by placing the Windows directory at the beginning of the PATH statement again.

Optimizing memory allocation

The more memory that's available to Windows, the faster it can run. So your system must have lots of memory and be configured correctly.

Since Windows uses only extended memory, you must ensure that your additional RAM isn't configured as expanded memory (e.g., through the EMM386.EXE driver). Also, verify that the appropriate extended memory driver, HIMEM.SYS or HIMEM.EXE, is entered as a DEVICE statement in your CONFIG.SYS file.

Don't install any software that will remain resident in extended memory. For example, installing a virtual disk drive using RAMDRIVE or VDISK will make that segment of memory unavailable to Windows.

If you're using a hard drive cache program, such as SMARTDRIVE, it should be allocated only a minimal amount of memory. Although such programs help optimize hard drive access, their efficiency doesn't increase with the amount of memory that they are given.

So, you shouldn't use more than 2 Meg of RAM for SMARTDRIVE. Additional memory won't increase the program's effectiveness and will only take valuable memory away from Windows. This may

actually cause Windows to access the hard drive more frequently, so that ultimately Windows operates less efficiently.

Windows Version 3.1 has an updated version of SMARTDRIVE. On a PC with 4 Meg of RAM, this hard drive cache program will reserve 1 Meg of memory as cache space, when used under Windows.

Windows NT 3.1

Microsoft released a new version of Windows called Windows NT (New Technology) in the summer of 1993. Unlike its predecessors, Windows NT is actually a full-fledged operating system that will not only fully use the 32-bit mode of 386 and 486 processors, but will also be able to exchange programs with other computer systems, such as Apple or NeXt systems.

System requirements

Installing Windows NT 3.1 requires at least 20 diskettes or a CD-ROM drive. It requires 12 Meg of RAM and 70 Meg of hard disk space. Unfortunately, NT is not compatible with any disk compression software although there are plans to release a DOS 6 compatible DoubleSpace in future versions.

If you've become familiar with the user interface of Windows, you'll quickly become accustomed to the user interface of NT. However, this is also a disadvantage because the NT offers less object-orientation and task automation than you may need.

Network support

NT has built-in support for networking that is compatible with Microsoft's LAN Manager networks. Both administrative and end-user functions are available through the Windows interface. Additional networking is possible with a limited set of command line-based TCP/IP tools for use with UNIX networking. The NT also comes with a single-user built-in version of Microsoft's RAS (remote access services) that allow users to dial into Windows NT from a remote Windows NT or Windows for Workgroups system.

Although NT does not yet include Novell NetWare support, there are plans to support over 100 network cards as well as additional NetWare support.

Because the hardware requirements for NT is restrictive, be very careful when upgrading to the NT. Be very specific when discussing your system and requirements with your dealer.

Windows for Workgroups

Windows for Workgroups is a full network implementation of Windows, intended to let multiple users on a network card interact. These groups can access files and applications, and even send EMAIL (Electronic MAIL) to one another.

What next?

Windows 4.0, a stand-alone implementation of Windows (i.e., it will run without MS-DOS) is currently in the testing stages. Windows 4.0 is probably intended to compete with the next subject in this chapter - IBM's OS/2 operating system.

3.3 OS/2

When IBM introduced OS/2 in 1987, it hoped that it would eventually replace MS-DOS. Even in 1987 it was obvious that MS-DOS needed to be replaced by a more up-to-date system. The infamous 640K DOS memory limit often resulted in problems with applications, which needed more memory to operate properly.

Microsoft tried to solve this problem with the LIM EMS standard. However, this process couldn't be used on all PC systems and was too slow because switching between EMS pages (paging) was time-consuming. DOS's inability to make the increased performance of new processors accessible to applications, especially by failing to use the 286's Protected mode with its virtual memory management, also increased the need for a new operating system.

The first 286 operating system

When IBM's new PS/2 personal computer series was introduced on the PC market, the new OS/2 operating system, which Microsoft helped develop, was also introduced. This new operating system, which would have several special features, promised to solve all the problems inherent in DOS. We'll discuss some of these special features, many of which were actually released with Version 1.1, later.

Enlarged address range

OS/2 can run the Protected mode of 286 and later processors. This mode lets the 286 physically address 16 Meg of RAM. So it's actually possible to install this much memory under OS/2. If this isn't sufficient, it's also possible to address an amazing 1 gigabyte of virtual memory. By temporarily storing data on the hard drive, you can run applications of almost any size with this operating system.

Multitasking

True multitasking

OS/2 also uses another important advantage of the 286. This operating system can run two separate programs simultaneously. Actually, multitasking doesn't happen simultaneously. Instead, the processor constantly switches from one program (task) to the other.

Unlike Windows, for example, OS/2 uses a fixed time frame, which is determined by the operating system core, to switch between active tasks. Because of this, a task, which is stuck in an endless loop, can be ended. This process prevents multitasking deadlock, which occurs when one of these tasks cannot be avoided.

Network capability

OS/2, unlike MS-DOS, was designed to support PC networks. The operating system has its own server program, called the LAN manager, which is responsible for coordinating data transfers within the network. PCs operating under OS/2 can be configured as file servers as well as workstations, and can even be networked with MS-DOS computers.

Integrated user interface

Improved Windows

The Presentation Manager, which has been a part of OS/2 since Version 1.1, provides a user-friendly graphical user interface. This interface features a well-developed window operation, which is very similar to the Windows structure.

Actually, the Presentation Manager is an offspring of Windows 2.0, which was on the market during its development. However, unlike Windows, it isn't a separate part of the existing operating system. Instead, it represents the central operating system interface into which all standard functions of OS/2 have been integrated.

Compatibility

DOS compatible

One of the concerns users have about purchasing a new operating system is that it won't be compatible with their existing programs. The developers of OS/2 have also considered this and have integrated a compatibility window into their Presentation Manager. This window ensures that all DOS programs can still be used and that some applications, which don't need to access hardware directly, can even be operated in the background. OS/2 also permits the user to switch to a DOS shell that's identical to the one found in MS-DOS 3.3.

Another feature lets you, while booting your system, select whether DOS or OS/2 should be loaded. This makes it possible to install both operating systems on the same hard drive.

Too expensive?

You're probably wondering why, if OS/2 offers so many advantages, it isn't used by more PC users. We're not sure why this excellent system hasn't firmly established itself among PC users. Perhaps there isn't only one reason why it hasn't been able to replace MS-DOS on a larger scale. Several factors are responsible for this situation. For instance, the marketing strategy for OS/2 may not have been the best. Also, its relatively high price deterred many PC users from purchasing this otherwise excellent operating system.

Another reason for OS/2's limited use is that it's ahead of its time. The hardware requirements for this operating system were especially impractical. Since a good XT still costs several thousand dollars and an AT isn't attainable for many PC users, these requirements weren't feasible for most users.

As we mentioned, OS/2 required a 286 CPU or higher, as well as a minimum memory capacity of 1.5 to 2 Meg. When OS/2 was released, many 286 motherboards weren't even set up for memory expansions and an Intel Aboveboard with 1 Meg of RAM was extremely expensive.

Therefore, OS/2 was used primarily by professional computer users. It was also successful in PS/2 systems, which IBM included with this operating system.

As hardware prices began to decrease, Microsoft released Version 3.0 of Windows. Because of its more appealing interface and lower price, Windows was more successful than OS/2.

New standard?

However, IBM didn't give up and, in 1992, released Version 2.0 of the OS/2 operating system. This version of the operating system, developed only by IBM, was intended to outperform any other available system. IBM hopes that it will become the new standard operating system for PCs. Since this version is less expensive than the previous versions, more PC users should be able to afford it.

The first true 386 operating system

The main difference between OS/2 2.0 and its predecessor is that this new version is a true 32-bit operating system. So, this system can be run only on 386 or 486 systems. However, since hardware prices are decreasing, this shouldn't be an obstacle to OS/2's success on the market.

OS/2 2.0 is completely DOS compatible, including Version 5.0 of DOS. It even includes a complete version of Windows 3.0. This lets you run a DOS program, a Windows application, and an OS/2 application simultaneously in separate windows. DOS applications even run faster under OS/2 than under DOS alone because of OS/2's 32-bit structure.

OS/2 2.1 features

This operating system runs under the Protected mode of the 80386 processor. Since the 2.0 version of OS/2 now also uses the powerful 32-bit commands of the 80386, it no longer runs on 80286 systems, unlike 1.x versions.

OS/2 2.1 uses a flat memory model, a 32-bit memory management system. This enables OS/2 2.1 to manage up to 4 gigabytes (4096 Meg) of linear memory. This memory is managed in 4K segments, which can, if necessary, be divided into smaller segments. When RAM is required, OS/2 2.1 swaps currently unused 4K segments onto the hard drive. This memory management method (virtual memory) allows OS/2 to allocate more memory than the system actually possesses.

OS/2 2.1 is a multitasking/multithreading operating system. This means that several programs can be executed simultaneously (multitasking) and that within these programs, independent program segments can also be executed simultaneously (multithreading). This capability is especially useful on multiprocessor systems. In these instances, the operating speed can be increased significantly.

With multitasking, the computer can execute several tasks simultaneously. For example, you could start a database application and start sorting a large database file. Then you could switch to the OS/2 command line and use the FORMAT command to format a new diskette.

You then switch back to your word processing application to type a letter. All these tasks are executed side by side. You no longer have to wait until one task is completed before you can start another one.

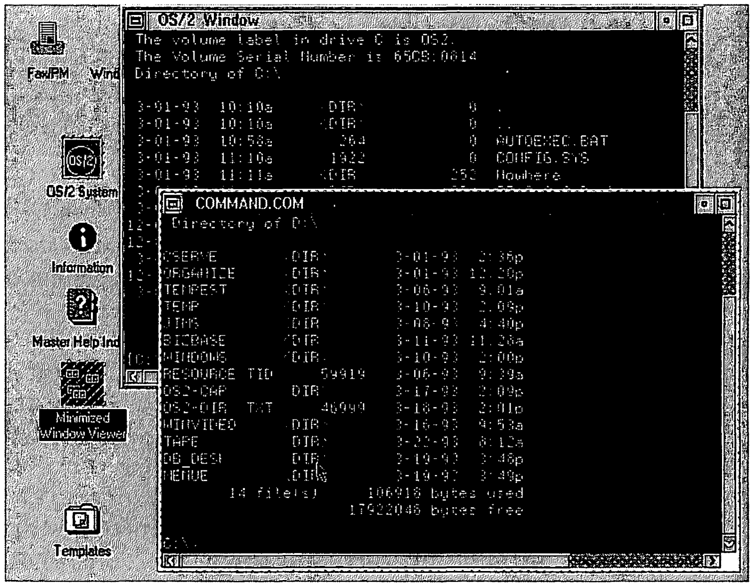
Multithreading is a type of sub-multitasking. Programs can consist of smaller segments, or threads, that are in turn executed simultaneously. For example, a printing operation could occur along with other program operations.

However, programs are simply threads themselves. Theoretically, each program or process is allotted up to 512 Meg of memory. Each process can contain up to 4095 separate threads.

Multiple virtual DOS machines

OS/2 provides DOS windows so conventional DOS programs can be executed. This enables OS/2 to simulate complete, virtual DOS PC systems.

Therefore, you can execute several DOS programs. Each program will run on its own virtual PC, each with up to 700K of available conventional memory, up to 512 Meg DPMI, up to 32 Meg EMS, and up to 16 Meg XMS.



Multiple Command windows

It's even possible to boot different DOS versions simultaneously, if desired, from diskettes in a window.

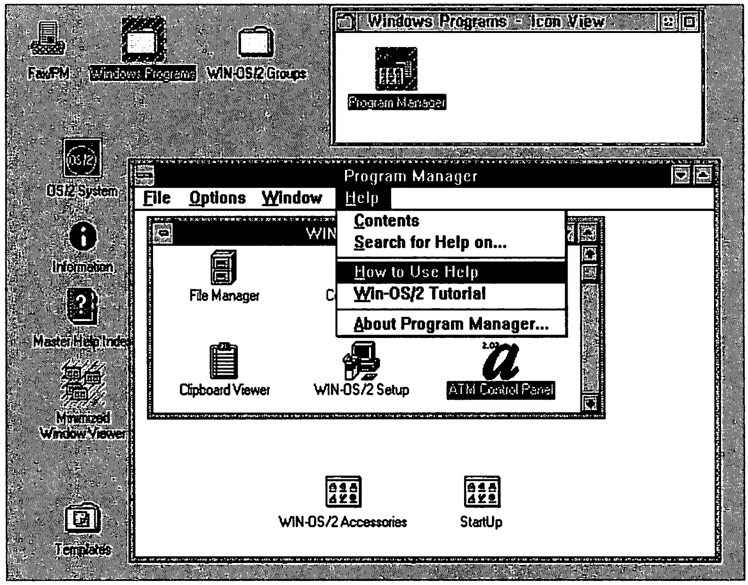
Windows support

You can run Windows programs under OS/2 2.1. You can execute them either in full-screen mode, perhaps with a special Windows video card driver, or in a window in the WPS (Workplace Shell).

Using a joint clipboard, you can easily exchange data between all Windows and OS/2 programs. Even DDE and OLE can be used.

OS/2 1.x

Older OS/2 programs still run under OS/2 2.1. Even most of the old drivers can still be used, although you should switch to the newer and more powerful 32-bit 2.1 drivers as soon as possible.

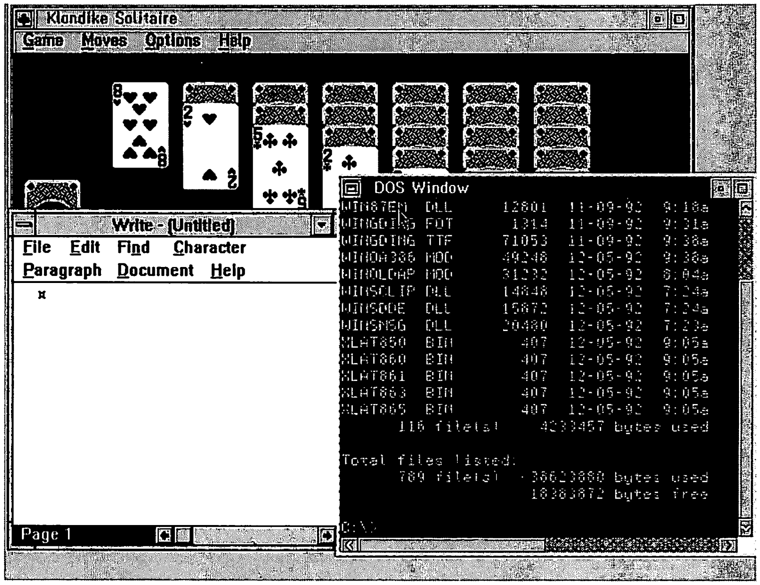


Windows applications can run under 2.1

Advantages of OS/2

Unlike graphical user interfaces, such as Windows, GeoWorks Ensemble, or GEM, OS/2 2.1 is an actual operating system. It isn't just a fancy DOS add-on. So, graphical user interfaces cannot really be compared with OS/2.

Another advantage of OS/2 is that its environment, unlike UNIX's environment, is familiar to DOS and Windows users. So DOS and Windows users can easily use OS/2. OS/2 2.1 also enables users to run a large amount of existing software, such as existing DOS, Windows, and OS/2 programs.



DOS, Windows and OS/2 software together

You can easily upgrade your OS/2 system by adding networking or multimedia capabilities. You could also expand the system so it's a network server.

Conflicts with video adapters

From what we've seen, the OS/2 operating system is extremely worthwhile, if you own a 386 or 486 system. However, OS/2 may encounter problems with a few special VGA cards that are equipped with a Turbo chip (e.g., for Windows). Cards using the Tseng ET4000 chip and a high-color mode may also encounter problems with OS/2 2.0. At certain times, the screen output may be lost unexpectedly.

However, the various hardware manufacturers most likely will adapt to this new operating system quickly. If this happens, these quirks will probably be corrected within the near future.

3.4 UNIX

UNIX, which was created in 1968, is one of the oldest operating systems. Despite its age, UNIX hasn't been updated dramatically. However, it is the most powerful operating system.

UNIX serves as a model

Many of the typical characteristics of MS-DOS and OS/2 are actually copied from UNIX. The most obvious of these characteristics is the tree-like hierarchy used in the directory system of these operating systems. UNIX also uses a main or root directory, which in turn contain different subdirectories.

OS/2 more closely copied UNIX's internal file structure. So, unlike MS-DOS, it's impossible for files stored on hard drives to become fragmented across non-adjacent disk clusters. This results in much faster data transfer to and from the hard drive, even when the hard drive is extremely full.

Many users, many programs

UNIX is a completely multi-user/multitasking system. This means that numerous users can work on the same computer, using different programs. It's also possible for a single user to run several different programs simultaneously. Unlike a single-user/singletasking system, such as MS-DOS, UNIX fully uses the processor's capabilities and resources. Under DOS, the processor spends much of its time simply waiting.

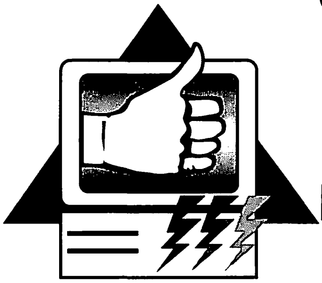
However, UNIX uses the full capabilities of not only the processor, but also the system's other hardware components. So, the more memory a system has, the better UNIX runs. Even 32 Meg can easily be used to their full extent by UNIX.

Highest hardware requirements

The hardware requirements of a UNIX system are its biggest disadvantage. The enormous power of UNIX demands extremely powerful hardware. The need for a 486 system with a full-size cache, at least 8 Meg, or better yet, 32 Meg of RAM, and a fast hard drive generally makes this operating system impractical for average PC users. The selection of programs available for UNIX is another reason why UNIX is mainly used by professionals.

One of the major advantages of the UNIX system is its portability, which enables it to be installed on computers with completely different structures and CPUs. Although this has permitted a very wide range of applications to be developed for UNIX, the specialized nature of these applications and the unfriendly nature of its user interface can quickly frustrate an average PC user.

However, in the professional realm, UNIX still has an extremely bright future. This is especially true because currently it's the only universal (i.e., manufacturer- and processor-independent) multi-user operating system available. However, the further developments of UNIX will definitely benefit single user PC systems.



CHAPTER

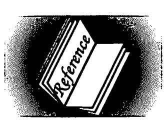
4 System Configuration

In the previous chapters we discussed the various components of a PC. Each of these components belong to one of the four basic groups (Processing, Storage, Input, and Output) within a PC. We discussed the individual elements and capabilities of these components. Also, we presented some ways to increase the performance of these components.

Ultimately, these groups must be combined into a single unit. This fact represents the biggest obstacle in upgrading and fine-tuning your system or assembling your own PC.

In this chapter we'll discuss the best way to configure PC systems. We'll discuss such things as the criteria to remember when purchasing a hard drive and which graphics card is right for your PC.

We'll also discuss the different ways to assemble a PC system. For example, should you try to get the most components for the least amount of money or should you carefully consider each component in the configuration?



In the second part of this chapter, we'll present the complete configuration for a sample multimedia PC system. In Chapter 9 you'll find complete instructions on how to assemble this system.

4.1 How PC Components Interact

Because of the number and diversity of the products that are flooding the PC market, it's difficult to make informed decisions about the configuration of your PC system.

In addition to a thorough knowledge of the hardware components involved, you also must have some experience with the software

products you plan to use. This is important to determine how these products will be affected by changes to the configuration.

The two following tips are extremely important to PC configuration. We'll discuss these later in the chapter.

All PC systems are different

First, remember that your personal computer is an individualized, or rather a personalized system. A PC system that's perfectly suited to your needs and applications may not be powerful enough for another user. So whether a given configuration is good or bad can be determined only in the context of the system's intended use.

Configurations change constantly

Secondly, your needs and demands on your PC will constantly change. So, the "ideal configuration" at any given time can be very different than an earlier configuration.

It's acceptable to plan ahead, but you shouldn't believe that each new upgrade or component is the final one you'll ever need. This approach is both unrealistic and costly. The best purchase is usually the one that fulfills your present needs and the needs you foresee for the immediate future (e.g., the next six months).

Usually third party PCs are a combination of all types of components. So, some computer stores may have 486SX systems with 1 Meg of RAM and a 40 Meg hard drive and others may have 486SXs only in tower cases. It may seem these systems are put together only by looks and price.

However, an effective configuration is the basis of every capable PC system. The configuration criteria is completely different when a system is configured entirely from scratch as opposed to when an existing PC system is upgraded by exchanging or adding components.

Since the differences in price between different PC components is becoming increasingly smaller, you can usually afford to buy the more powerful component. For example, the difference in price between a 386SX and 386DX motherboard is approximately $160.

This is especially true with today's AT bus hard drives. For example, the price difference between a 40 and 120 Meg hard drive is approximately $150. Also, 286 motherboards are about only $30

cheaper than identically configured 386SX boards with a 16 MHz clock speed.

When you consider the small differences in prices of many components, it's obvious that configuration decisions are often a matter of splitting hairs, or perhaps dollars. However, if you use good judgment and you plan your system with realistic expectations, you may save hundreds of dollars. This is illustrated in the following example.

Select your configuration carefully

Jan, a graduate student, wants to assemble a PC system that she can use for word processing. Her friend Barb runs her own word processing business, and is looking for a PC she can use for her work.

Although her system should be flexible enough for future upgrades, Jan won't place a lot of demands on her system. So a 386SX with 16 MHz and a monochrome monitor is enough. The size of the hard drive isn't very important. As long as it's possible to swap the motherboard, this would be the perfect system for Jan. This system should cost about $800.

Barb's word processing business, however, places different demands on a PC system. So she'll need a very powerful word processing program. She'll also be printing documents regularly.

Since she must be able to continue working while printing, she'll need a PC that's able to perform several tasks at once and is equipped with enough memory to print documents in the background. This, in turn, requires a word processor, such as Word for Windows, that meets these requirements.

With these requirements, Barb needs at least a 386DX running at 25 MHz. This system must have at least 4 Meg of RAM if Word for Windows is used. Her hard drive shouldn't be smaller than 80 Meg. A monochrome monitor is also sufficient in this situation. This system should cost about $1,300.

Both systems will be used to process text documents. The first system needs only a basic set of reliable components. Obviously, the PC that will be used for Barb's word processing service must meet higher demands.

PCs are expensive toys

Suppose that you want to configure a PC that will be used mainly for playing computer games. First you must consider the types of games you'll be playing.

Simulation games (i.e., programs that use intensive graphics) place the most demands on a PC system. For these games, you'll need a 386DX running at 33 or 40 MHz with 4 Meg of RAM, and a fast hard drive with at least 80 Meg of disk space. A color monitor is also essential. Depending on the simulations you'll be running, your system may also need a math coprocessor. This system should cost about $1600-$1800.

If the PC will be used for less demanding games, such as action or strategy games, a simple 386SX PC with 1 Meg of RAM, a small hard drive, and a VGA color monitor should be sufficient. This system should cost about $950-$1100.

As we saw in the previous example, the same types of applications place different demands on the PC system. This results in different configurations. So, the demands made by each application are always the deciding factor.

Obviously PCs are intended for more than just playing games or for using a single word processing program. So, the demands placed on most systems are usually more varied and complex.

If you've decided on a 386 system, you should determine whether you want to work with a graphical user interface. If you do, then your best choice is a 386DX processor with a minimum of 2 Meg of RAM.

If you'll be using Windows, remember that Windows and its applications tend to use all the memory they can get. This especially applies to hard drive space. Therefore, the hard drive shouldn't be smaller than 80 Meg. Generally it isn't worthwhile to invest in a particularly expensive video card. Any standard VGA card with 512K of video RAM can fully use the capabilities of a normal 14" color monitor.

However, for professional graphics applications you should consider a 486 system. These types of applications also require a more specialized graphics card, if the system also has a large

monitor (at least 16"). This enables the card's higher resolution to be displayed.

A different ball game: Upgrading

If you're upgrading your PC and are planning to exchange your motherboard, you need to take a different approach to system configuration.

For example, suppose that you're exchanging your 286 motherboard for a 386 board with 33 MHz. Most likely you should also consider replacing the disappointingly slow MFM hard drive system with an AT bus drive, especially if the capacity of the existing hard drive has been exhausted.

However, if the motherboard was swapped mainly to obtain improved processor performance during lengthy mathematical calculations, and the system is otherwise only used for word processing purposes, hard drive performance isn't very important. In this case, the existing hard drive may be adequate.

If your system's refresh rate is too slow, this doesn't necessarily mean that you should switch to a higher motherboard. Usually this problem can be solved by using a faster graphics card and more video RAM.

Upgrading saves money

Upgrading a PC system requires different considerations than assembling a new system. Also, it's usually cheaper to upgrade, if the existing system is based on a 286 motherboard and standard components, than to trade your PC for a new one.

For example, to upgrade to a higher processor, you must simply install a new motherboard and, perhaps, a new hard drive system. However, the case, floppy disk drives, graphics card, and keyboard of your existing PC remain. If you replace your entire system, you would also have to buy all new components.

However, if you're going to purchase a new PC, you should select or assemble a system that's tailored to your specific needs and applications. You should also ensure that this system is flexible enough to be upgraded to meet your future demands. Remember that each dollar you spend today on something you don't need until

tomorrow is money wasted. This is because a component's price decreases the longer it's been on the market.

If you're upgrading your system, consider your specific needs. Selective upgrading involves thinking of tomorrow's step today, so your next upgrade will be as easy as possible. Upgrades will always be compromises between the technology and power you feel you need and the amount of money you're willing to spend.

4.2 Windows 3.1 and a Multimedia PC

In the previous section we discussed the types of demands that are placed on a PC system by the most common applications. Now we'll use an example to demonstrate the complete configuration of a PC system.

Windows has many advantages

The system that we'll configure in this example will operate under Microsoft Windows. We chose Windows because it offers PC users the first standardized graphical user interface. All functions can easily be selected using your mouse, and its interface is easier to use than the unfriendly DOS command line.

Another advantage that has helped Windows' popularity is its ability to run several applications simultaneously. Multitasking lets you switch back and forth between these applications. Since Windows also fully uses the PC's memory, users can finally use all the capabilities of their systems. This is impossible under DOS alone.

Today an almost complete selection of applications is available for Windows. Several standard applications are even included in the Windows package. Windows users can also use their existing DOS programs because these can easily be started from the Windows interface.

As you can see, there are many reasons for running your system under Windows.

Now we'll determine how the ideal Windows PC is assembled and which criteria you should consider to create an effective system.

The biggest disadvantage of Windows is its comparatively slow speed. If you're already using a version of Windows and have previously worked with DOS, you probably know what we mean. We'll try to determine how this inherent weakness can be minimized. Therefore, the goal of our system configuration is to provide a fast Windows environment.

Determining which motherboard to use

A 32-bit processor is needed to use all the Windows functions. We recommend using at least a 386 CPU with a 33 or 40 MHz clock speed and an external cache of 64K. Technically, even a 25 MHz 386SX would probably be sufficient, especially if it's equipped with an external cache. However, today the additional amount needed to purchase a DX board with 33 MHz is so minimal the increase in performance is well worth the money.

When to use a 486

Whether using a 486 board is a good choice isn't quite as clear. If you're using applications that work with vector graphics, such as CorelDraw! or another graphics or desktop publishing program, the higher performance of the integrated 486 chip would be a worthwhile investment.

While a 486 system isn't much more expensive than a 386 system with a coprocessor, it offers almost twice the performance. However, if none of your applications will actually use the integrated coprocessor, the 486 wouldn't be useful. Instead, you could spend the extra money on additional memory, for example.

Also, you shouldn't use a 25 MHz 486SX board. Although this chip will run slightly faster than a 33 MHz 386 CPU, the future addition of a math coprocessor would cost much more than a 387 math coprocessor.

How much RAM?

Use as much RAM as possible

You should have as much RAM as you can afford. Windows uses a lot of memory. Each Meg of memory that you add to the system will reduce the number of hard drive operations, since less data will have to be stored in temporary files. You'll notice a definite difference between 2 and 4 Meg of RAM.

The extra memory results in considerably faster Windows operation. Because the price of RAM chips continues to decrease, adding memory involves a relatively small investment. So, it's possible to equip your system with 8 or 16 Meg of RAM. This is especially helpful if you'll be running larger applications or will frequently use your system for multitasking. You shouldn't underestimate the impact of additional RAM capacity.

Which hard drive?

Use the fastest hard drive possible

You should use the fastest hard drive possible. Even if your system has enough memory, Windows will need to access the hard drive frequently. Since this operation involves mechanical movement, it's the slowest of all Windows operations. You can speed up this process by installing a cache hard drive. These hard drives are equipped with their own cache memory which is used to store frequently accessed information, such as the FAT.

HDD controller

One of the factors of hard drive performance is the system's data transfer rate. Since this value is directly related to the hard drive controller, you shouldn't try to save money on this component. We recommend using a good AT bus controller with integrated cache memory. As RAM prices continue to decrease, it will be easy to enlarge this cache in the future.

Hard drive capacity not always important

The capacity of the hard drive system is actually less important than you may think. The average capacity today is about 100 Meg, and it's still rising. So you should gauge the hard drive capacity according to the size of the applications you'll be using.

However, you should take advantage of the increased system speed that's possible by using a permanent swapfile. To be truly effective, this swapfile should be allotted as much as 10 to 20 Meg of disk space. However, remember that a hard drive becomes slower as it fills up. This is especially true as the files become more fragmented.

Which graphics card?

The refresh rate is the time your system takes to redraw or redisplay an image on the screen. Some manufacturers claim their graphics cards can make Windows run up to 20 times faster.

Since Windows is a graphical user interface, much of its resources are used simply to display what you see on the screen. Usually every pixel that appears on your screen must be processed by the CPU. This means that your processor spends a certain percentage of its time just building the screen image. Sometimes the CPU is even forced to wait for the graphics card if the latter is running too slowly.

Although special graphics cards are capable of speeding up this process, they only affect this particular action. All other Windows operations still are performed at the same speed as before. So you should consider just how much your system is being slowed down by screen operations. You may decide that, instead of buying a faster graphics card, you can purchase another component, which may increase performance more significantly.

Must display 256 simultaneous colors

However, your graphics card should definitely allow Windows to display 256 simultaneous colors. Therefore, you'll need a super VGA card with a minimum of 512K of video RAM and a special Windows device driver that should be supplied with the card. Today such drivers are sold with almost every VGA card. They enable even simple graphics cards to reach high speeds.

You may have read warnings stating that you shouldn't run Windows in the 256 color mode, since this supposedly results in a much slower refresh rate. Although this mode does require more screen data to be processed than the 16 color mode, we haven't found that it actually slows down Windows. Actually, we've found that screen construction actually became faster in some cases through the installation of the 256 color driver supplied with the graphics card.

Let's summarize this hardware configuration. Our Windows PC consists of a 33 MHz 386 (or 486, in certain cases) motherboard with at least 4 Meg of RAM, a 512K VGA card, and a fast AT bus hard drive with integrated cache and a high transfer rate controller.

We'll use Windows Version 3.1, which not only runs faster than Version 3.0, but also has numerous improvements.

One of these improvements is the establishment of a multimedia standard for processing audio visual data. With this standard, Microsoft has also determined the minimal requirements that must be met by a multimedia PC system. These requirements are listed below.

Minimum hardware requirements for a multimedia PC system:

- 32-bit CPU, 386SX or higher
- 2 Meg of RAM or more
- 1.4 Meg 3.5-inch floppy drive
- 30 Meg hard drive or larger
- CD-ROM drive with D/A output, volume control, a minimal data transmission rate of 150K/second at no more than 40% CPU use, and an average access time under one second
- Audio card with:

  8-bit digital to analog converter with 22.05 and 11.025 KHz sampling rates, DMA capability, and its own hardware interrupt

  8-bit analog to digital converter with 11.025 KHz sampling rate and microphone input

  Music synthesizer

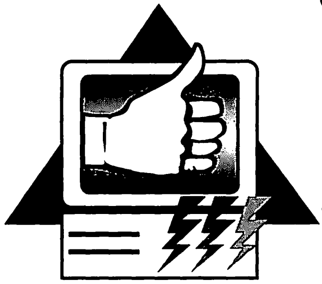
  Analog sound mixing capability
- VGA card
- MF2 keyboard
- Microsoft-compatible mouse
- MIDI interface
- Serial port
- Parallel port
- Game port

As we mentioned, these are the minimum requirements that must be met to use multimedia capabilities.

In terms of power and performance, the configuration we illustrated earlier exceeds these basic requirements. This configuration would simply have to be enhanced with a sound card with multimedia capability, such as the Sound Blaster Pro by Creative Labs, and the CD-ROM drive previously described. This would result in a PC that far exceeds the minimal requirements for multimedia operation.

In Chapter 9 you'll learn how to assemble this multimedia PC at home and install the required software, namely MS-DOS 5.0, MS Windows 3.1, and MS Multimedia Extension.

C H A P T E R



5 A Healthy PC Environment

Most likely you've spent long sessions in front of your PC monitor. You can spend hours working with a new program or playing an exciting computer game. Many of today's programs are so versatile and complex that it can easily take several hours to learn how to use them.

Because of the long hours spent in front of PC monitors, different organizations have thoroughly researched this aspect of computer use to determine any negative side effects. In this chapter we'll discuss the various ways you can make your PC environment both comfortable and safe.

5.1 Correct Setup and Adjustment

Higher resolutions aren't necessarily better

We'll begin with your equipment setup. Your monitor, keyboard, document holder, mouse, and perhaps your joystick should be positioned at equal distances from your eyes. This way your eyes won't have to refocus constantly as you use these different devices, which would needlessly tire your eyes.

A distance of about 20 inches is ideal. The characters on your screen should be large enough so they can be easily read even after longer computing sessions.

The ideal height for screen characters is about 0.1 inches (2.6 mm), and their width should be no less than 50% of their height. The greatest chance of eye-damage results from working with higher resolutions on screens that are too small, which results in characters that are too small. We discussed this problem in more detail in Section 2.3.

Although high resolution screens are wonderful for graphics, for longer computing and particularly word processing sessions, you should use the standard VGA resolution of 640 x 480 pixels.

Black on white is best

The objects within your range of vision should be non-reflective and as light as possible. The characters on your screen and the ones on your keyboard, are most easily recognized when they're black against a white or light gray background. This will place the least amount of strain on your eyes.

The sharpness of your picture is another important factor. So you should be particularly critical when selecting a monitor and graphics card. Flickering monitors must be avoided entirely.

The myth of monitor radiation

A topic that has caused much confusion and debate is the radiation emitted by computer screens. This topic has caused much anxiety among PC users. As a result, clever manufacturers were quick to use this concern as a selling point for overpriced monitors.

Immediately upon the release of a Swedish study that dealt with the effects of computer monitor radiation on pregnant women, several studies were commissioned. However, any screen that is shielded provides adequate protection.

Since monitors need to be shielded from outside interference anyway, they cannot emit excessive amounts of radiation. Most experts agree that it's much more effective to optimize other aspects of the work environment in eliminating or avoiding potential health hazards.

5.2 Ergonomics

Correct posture

One aspect that can help you avoid potential health problems is correct posture, the height of your keyboard, and the correct positioning of your PC components. Incorrect seating levels and poor positioning of your screen can result in permanent problems.

Your seating level is extremely important. It should allow you to sit without becoming fatigued. You should be able to move your back without feeling restrained.

Your thighs should rest fully on the seat surface and the edge of the seat should not press into your legs. Your feet should always be able to touch the floor. Shorter people may need to use a footrest of some sort.

In this sitting position, your hands should be freely movable about the desk surface, easily within reach of the keyboard and mouse.

This may sound complicated, but it's actually easily accomplished. Sit upright in your chair with your legs bent at a right angle and your arms resting on your desktop so they form right angles. Now adjust the height of your chair until it's in the proper position. Generally the best height for desk surfaces is around 28 inches.

By adding the average height of your keyboard, just over one inch, to this measurement, we arrive at a final height of about 29.5 inches. This is the height you'll want to attain.

To ensure the best working environment, you should invest in a quality chair and desk. Also, the surface of your desk should match your equipment (i.e., ideally a bright, non-reflective surface).

If you frequently spend long hours in front of your computer screen, you should get regular eye examinations. This way you can catch potential problems before they become too serious.

Proper lighting is important

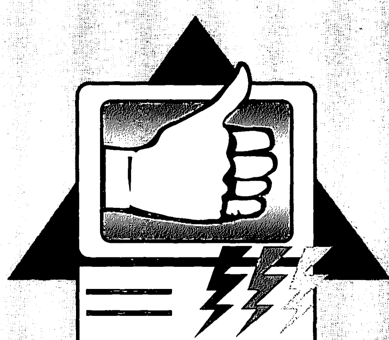
Your work area should be brightly lit. Lighting designers specify an illumination level of approximately 700 lux for computer workstations. The light source should emit white light. However, it's impossible to determine the exact illumination level without a light meter.

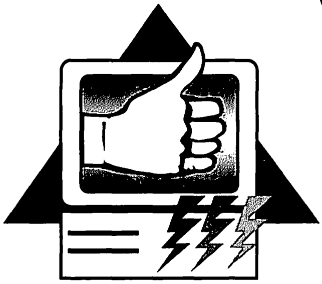
Brightness

Normally, your work area should be about twice as bright as the average living space. Seventy percent of this light should fall directly onto your work surface, the rest should be reflected (indirect) light. It's important the illumination of your desk surface doesn't produce any type of glare.

Section II

Upgrading In Detail





CHAPTER

6 Your PC Workshop

Now that Section I has introduced you to your system's hardware components and functions, you can determine which types of upgrades are necessary for your PC.

Section II will teach you how to make the necessary hardware changes in your system, and even how to build your own PC.

In this chapter, we'll discuss the basic requirements for such an undertaking. Please read the information presented in this chapter very carefully. This is true even if you're already familiar with working on your PC. Although you may not need to follow each instruction, you may find new information, some of which may prove very useful in critical situations.

We don't want to discourage those of you who haven't performed any type of maintenance on a PC system. Not every point is crucial; with a basic understanding of any given procedure you'll be able to complete the most important tasks correctly.

6.1 Rules and Dangers

You may be afraid to modify your PC, especially if you never worked inside a microcomputer system before. A computer is a highly specialized electronic device; it's a complex maze of conductors and components that can be extremely confusing.

Don't worry or panic

However, you shouldn't worry about working with your computer. Let's compare this situation with using a complicated software package, for example the operating system. After using this software for a certain amount of time, you'll be able to work comfortably with this program, and even manipulate its configuration.

However, you don't have to understand the program's source code to do this. Similarly, there is no need for you to completely understand the maze of components in your PC system in order to modify it.

No technical knowledge required

Although you must have an overview of how the individual components in this system interact, you won't need the technical knowledge that went into the design and construction of this hardware. Here again, the open architecture of the industry standard simplifies things by allowing major component groups to be exchanged.

Modifying your PC system also doesn't require as many manual skills as you might think. Certain repairs, particularly replacing defective components, may require using a soldering iron or multimeter. However, these situations rarely occur.

For most of the operations we'll discuss, you'll need only a screwdriver. You'll see that installing, removing, or exchanging most components doesn't require any special skills.

If you can assemble a simple modular bookshelf, you can install a second floppy disk drive in your PC. Also, if you follow these tips and guidelines, you probably won't encounter any problems.

TIP #1

Take your time

Your biggest enemy is haste. Often, small mistakes will emerge later as problems which are extremely difficult to trace. Take your time and go over each step twice. If you're ever in doubt about something, it's better to go back and reread the appropriate chapter.

TIP #2

Always read everything first

You should never start modifying your system before reading the appropriate chapter in this book completely. Begin your work only when you're familiar with all the details and understand the entire operation.

After you've answered all the questions that you may have about the operation, you can begin. Otherwise, you may suddenly

realize, after you've disassembled your PC, that you're missing a part or that the planned modification isn't feasible on your particular system.

TIP #3

Never use force

All socket and screw connections in your PC should fit together and come apart easily and without using force. Most connectors are one-way connectors that are designed to hook up in only one direction. This prevents polarity reversals.

However, with enough force, these connectors can also be connected incorrectly. The resulting reversal in polarity can cause serious damage to your system's hardware.

Therefore, you should immediately become suspicious if any step in your operation seems to require an excessive amount of strength or force. Double-check the procedure and proceed only when you're absolutely certain this is the correct way.

TIP #4

Ground yourself

Static electricity is dangerous

Electrostatic charges can easily reach 2000 volts or more. Although the small amount of current released in the discharge of this voltage may be harmless to humans, it can be fatal for computer components. CMOS components are particularly susceptible to this type of damage.

Sometimes even a charge of just over 5 volts is enough to ruin such a component, which may ultimately result in a ruined motherboard. Therefore, you should always discharge any static electricity that may have built up on your body before touching any electronic component.

The most reliable way to do this is to wear an anti-static wristband that's connected directly to an electrical ground. However, frequently touching a grounded object, such as the PC's chassis or a plumbing fixture, will achieve the same result. Remember, always touch your PC's chassis before handling any other component.

TIP #5

Never open your monitor

You should never open your monitor under any circumstances.

CAUTION

The internal components in your monitor contain voltages high enough to pose a serious risk of injury or even death. This is true even when you've switched off your monitor and disconnected the power cord.

Various components within the monitor store electrical charges that could violently discharge this energy even days after the monitor was last used. Also, there is very little you can do with a defective monitor. Instead, you should consult a qualified technician.

TIP #6

Switch off everything

Do not try to repair a running PC. This is especially true when installing an expansion card. This can quickly lead to a damaged motherboard or expansion card. Also, if you do this, you may harm yourself.

TIP #7

Unplug the power cord

Always unplug the power cords of every device in the system on which you'll be working. This way you'll not only prevent yourself from being electrocuted on poorly insulated power plugs, you'll also prevent the device from being accidentally switched on while you're working.

CAUTION

The power supplies used in PC systems are supplies in which high and low voltages aren't positively separated. It's therefore possible to encounter 120 volts anywhere within the power supply.

Even a disconnected AC cord is no guarantee for working with your power supply. Certain components within the power supply can retain an electrical charge until long after the system has been switched off.

Qualified technician required

You'll only need to open the power supply unit to install a new ventilation fan. Any power supply repairs should be left to a qualified technician.

TIP #8

Position your components securely

Ensure that your keyboard is stored in a safe place. Users often move the keyboard aside if it isn't being used. Consequently, it can fall off the desktop.

Also, remember the cables and power cords found behind your PC include your monitor cable. Therefore, placing your monitor too close to the edge of the monitor stand or table may lead to disaster.

TIP #9

Watch out for power cords

Try to keep your floor as free of cords and cables as possible. You may want to place your power strip on your table or desktop. Make certain your cords are long enough so they have some slack.

TIP #10

Keep food, liquids, and cigarettes away from your computer

Avoid spilling coffee, soft drinks, or other beverages onto the motherboard. Cigarette smoke can also damage your PC.

TIP #11

Use the correct screws

Unfortunately, not all screws in your PC are standardized. Screws differ not so much in diameter as in thread pitch. By forcing the wrong screw into a mounting hole, you can, for example, ruin the threads of your new floppy drive.

Different threads

If a screw is difficult to tighten, check whether its thread matches that of the nut or mounting hole. The length of screws is also important. Various hard drives, for example, must be mounted with extremely short screws. Longer screws may penetrate too far into the housing and permanently damage electronic components on the interior.

TIP #12

Keep small parts together

Frequently screws can fall into the power supply unit through the fan opening. Place all small screws and parts in an appropriate container, such as a paper cup.

If you drop something, immediately stop whatever you're doing until you've located it. Screws that fall into the power supply through the ventilation slot could eventually cause serious damage to the power supply of the computer long after you've forgotten the screw.

TIP #13

Keep tools on the worktable

Never place tools in your PC. It's very easy to forget something that subsequently may lead to serious problems. It is best to reserve a certain area on your worktable solely for your tools. Then the tools are always handy and easily found.

TIP #14

Keep a log

You should always write down settings before you make changes. For example, when changing DIP switch or jumper settings, write down or draw the original configuration BEFORE changing that configuration.

When you must experiment with different settings, it's important to write down which combinations you've already tried, along with their results.

TIP #15

Test everything before reassembling

Don't reassemble your PC until you're absolutely certain that everything runs and your PC is working properly.

This can be particularly helpful when adding floppy or hard drives to your system. Ensure that you did not forget anything. Are the circuit boards screwed down tight? Are the cables correctly reattached? Are there any remaining screws?

6.2 Tool Box

Your PC is a complex maze of conductors and chips. So, you probably think that you need a large collection of tools in order to modify your PC system.

Modular simplicity

However, this isn't true. For the most part, the components of your PC are assembled in standardized modular component groups. These modules are usually connected through a simple plug, a socket, or through rail connectors. Although certain repairs will actually require using specialized equipment, even with the required skill and knowledge, these repairs are generally not worth the time or money.

Therefore you don't need to run out and buy yourself an oscilloscope. Almost all the operations that we'll cover in this book can be performed with the tools that are found in any household.

Essential equipment

The following tools and equipment are essential for effective maintenance of your system's hardware:

- *At least two formatted and write protected floppy diskettes*

We recommend using two diskettes because one diskette may be destroyed when you try to get your system running correctly.

Therefore, never use original diskettes for this purpose. Also, ensure that you've write-protected the diskettes on which you're working.

■ *A small standard (flat-headed) screwdriver*

A screwdriver is needed for removing and tightening screws. Small screwdrivers also work extremely well for setting DIP switches.

Usually any small flat-headed screwdriver is sufficient; models equipped with electrical test lamps in their handles are also perfectly usable.

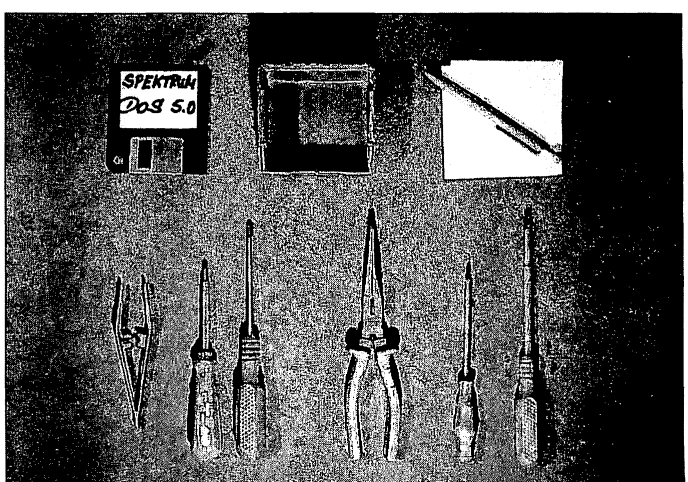
CAUTION

Do not use magnetized screwdrivers.

■ *A medium standard screwdriver*

This screwdriver is used, for example, to open the housing of your PC. You may not even need this screwdriver if the housing of your PC is mounted with Phillips head screws.

However, for the owners of brand-name PCs, such as IBM or Compaq, this screwdriver is a necessity.



Essential tools and equipment

Avoid stripped heads!

- *A small Phillips head screwdriver*

Since this screwdriver is used for almost all screws within your PC, it's your primary computer maintenance tool. Therefore, it should be high quality; good Phillips head screwdrivers have a snubbed tip, so the flanges engage deeply enough with the slots of the screw. These flanges should also have relatively sharp edges so the screwdriver is less likely to slip out of the screw head.

TIP

Don't hesitate to spend money for a good screwdriver. It will more than pay for itself by preventing stripped screw heads.

- *A medium Phillips head screwdriver*

This screwdriver is used primarily for removing your computer's housing. Ensure that it's good quality. Don't purchase a screwdriver with an extremely pointy tip.

- *A pair of tweezers*

Tweezers are needed to set jumpers and pick up various small parts that may have fallen into inaccessible areas of your PC. Plastic tweezers are ideal for this purpose, since they are non-conducting.

- *A pair of needle-nose pliers*

You'll probably use needle-nose pliers quite often in your upgrading work. This is especially true when changing jumpers. Needle-nose pliers are also used to pull off connectors that are difficult to reach and to loosen hex nuts, like the ones sometimes found on interface cards.

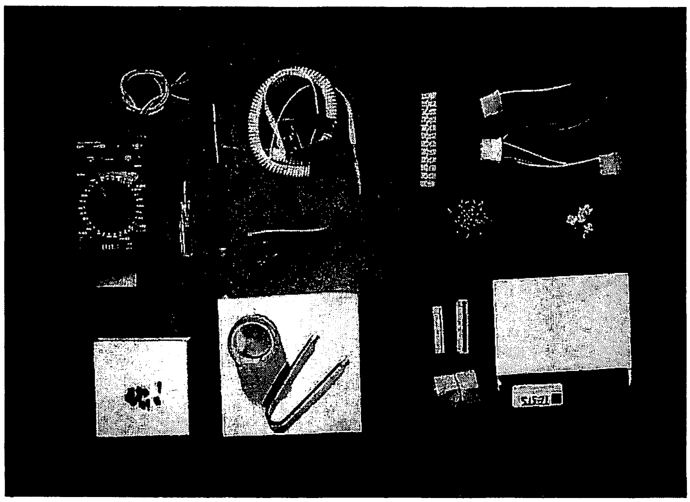
- *Paper and pencil*

You'll need these to write down important information for later use. Write down everything you remove and their proper connections. This can eliminate guesswork and problems later.

■ *A small container*

Use a small container (e.g., a small cardboard or plastic box, or paper cup) to store small parts and screws. You can even use a clean and empty coffee mug. However, be sure that whatever you use doesn't tip over easily.

Other tools



Useful additions to your toolbox

■ *Permanent marker*

A dark color marker will allow you to highlight parts and connections in your system. This can help you, for example, identify pin 1 of your floppy drive even after you've installed it.

■ *An anti-static wristband*

Using an anti-static wristband is the most reliable way to prevent electrostatic damage to your hardware components. You can keep the grounding wire out of your way while you're working by simply running it through the sleeve of your shirt.

Some anti-static wristbands have grounding wires that are much too short. In these cases, it's best to lengthen the wire by either soldering or clamping additional wire to the end of the grounding wire.

■ *A diskette containing a hardware diagnostics program*

If you own a program, such as CHECKIT! or DIAGS, make a working copy on a separate diskette and keep it in your PC workshop. These programs can be extremely helpful in finding errors or configuring an I/O port.

■ *Several blank formatted diskettes*

Use these diskettes to check the operation of your floppy drives. You also need to keep empty diskettes handy for eventual data backups.

■ *An extra short screwdriver*

Use this screwdriver to reach screws in tight places. Sometimes you'll even need to pull out expansion cards to maneuver a longer screwdriver within your PC. A short Phillips head screwdriver can provide a much easier solution in these instances.

TIP

We've found that special short screwdrivers with exchangeable bits are particularly helpful, allowing both standard and Phillips heads to be used with the same screwdriver. You'll find such screwdrivers in automotive supply stores.

■ *A hex wrench*

Hex wrenches are available as open end, box end, and screwdriver-type wrenches. They are also available as socket sets that are used with ratchet drivers. This type of wrench simplifies the installation of hex nuts on interface cards or your motherboard.

■ *A small file*

Occasionally a small file is needed to remove small imprecisions so that parts can fit together correctly. Often plastic castings will still have small burrs which can interfere with the operation of your PC's power switch. These burrs can easily be removed with a small file.

CAUTION

Never use a file to shape metal components of your PC's hardware. You'll never be able to completely remove the metal shavings from the interior of your PC!

- *IC insertion/extraction kit*

These kits, available from an electronics supply store, are used for removing RAM chips and other ICs without damaging their sensitive contacts.

If you don't want to purchase this kit or you can't find one, you can also use the metal cover from one of your PC's expansion slots. Simply use the short perpendicular end to gently pry up the chip that must be removed.

- *A sharp flat knife*

A simple kitchen knife with a flat blade is also useful. You'll need this knife for trimming oversized spacers and custom made ribbon cables.

- *Non-conducting foam*

This can also be any sheet of non-conducting material on which you can place your motherboard while you're working on your system. It also serves as a perfect support for your hard drive while it's out of your system.

- *Extra jumpers (various sizes)*

In some cases you may need to add extra jumpers rather than removing jumpers to achieve the correct configuration. So you may want to keep several extra jumpers available in your PC toolbox. You'll find jumpers of all sizes at your local electronics supply store.

- *Different standard size screws*

These can be extremely helpful if you misplace or lose a screw from your PC.

■ *Several spacers*

These are needed when you remove or reinstall your motherboard. Since it's fairly easy to damage these spacers when you remove them, it's a good idea to have extras available.

■ *A roll of electrical tape*

Ideally the tape should be fabric-reinforced. We've found that this type of insulating tape is more durable and also adheres better.

■ *Several wire connectors*

These connectors are inexpensive and are available in any electronics supply store. Don't select particularly long connectors, because you'll probably have to trim them anyway.

■ *A Y power splitter*

Often users begin to install a new hard drive and then discover that the power supply doesn't provide an extra power connection. If you're not sure whether your PC is equipped with extra voltage supply connections, you should include one of these power splitters in your PC tool box. These are also available in your local computer or electronics store.

■ *Post and card connectors, ribbon cable*

These are all the items you'll need to assemble your own floppy or hard drive cable. Perhaps you'll need such a cable when installing a 3.5-inch drive in your system, or you may need a cable extension for a particularly tall tower case.

■ *A hammer*

A hammer may be needed to help mount the crimp connectors on the ribbon cable mentioned above. Any normal household or woodworking hammer will work.

■ *Braided cable and connectors*

Use only stranded or braided cable for your wire connections instead of single-conductor wire. If you use single-conductor wire, future problems through broken wires will occur.

- *A continuity tester*

This slightly specialized device is used only to trace problems in suspect wire connections, or in testing the polarity of the power switch on a new PC housing.

Since you probably won't need a continuity tester, don't purchase one until it's necessary.

- *A soldering iron and rosin-core solder*

As we mentioned, we won't discuss repairs that require a soldering iron. However, if you're familiar with the correct use of this tool, you may find it quite useful in repairing faulty cable connections. A properly soldered connection is generally much more reliable than a crimp connector.

CAUTION

Be careful not to melt adjacent cable insulators. Also, never solder over your PC or any other exposed component. Doing this will most likely result in permanently damaging a component.

- *A multimeter*

If you don't already own a multimeter, you won't need to purchase one for your PC workshop. However, if you're familiar with a multimeter, it may provide valuable information in tracing problems, for example, with your power supply.

6.3 Tips For Your PC Workshop

As the tools you'll use to work on your PC should meet certain requirements, so should the place where you'll be working on your PC.

Remember that mistakes are less likely to occur if your work environment is organized. Therefore, you should select a place where you can work without distractions.

Give yourself enough space

Select a place where you won't be interrupted. Also, ensure that there is enough space and sufficient counter or table space for the different hardware components and tools. A large table that you can walk around is ideal. This will allow you to access your PC from all sides, without having to constantly rotate or move it.

Don't underestimate the amount of space you'll need. Remember that a PC with its monitor and keyboard can easily take up an entire desk even when it's assembled and operating.

There should also be ample, glare-free lighting. You must be able to recognize minute details, such as black type on dark brown components.

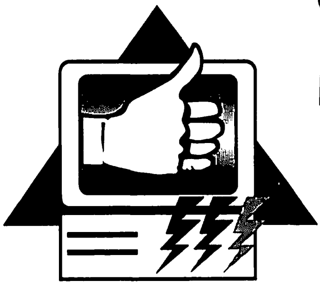
Work area

You should also have enough electrical outlets. Multiple-outlet power strips are ideal because they remove the hazardous maze of power cords on your floor. Such power strips usually include a main switch, which enables you to switch off power to all the components connected to the strip at one time.

Your workspace should also include a chair. Many different operations can be performed while sitting, and you'll frequently need to read various manuals and documentation.

So, to summarize, work in a well-lit room that's free of distractions. Use a free standing and sturdy table that you can reach from all sides without tripping over cables or wires, and keep everything that you'll need within easy reach.

This is the ideal setting; sometimes all of these conditions aren't possible. However, remember that the time you spend setting up your workspace also depends on how comfortable and confident you are about working with your PC.



CHAPTER

7 Installing Your Components

The following sections discuss the practical aspects of expansion and upgrading. We covered theory in the preceding chapters (please consult those sections for technical details).

Please follow these instructions as closely as possible. Take advantage of our experience and trust us. We have good reasons for telling you to do something a particular way.

Not everything will work right away. However, don't give up after the first try: Stay calm and concentrate on what you're doing. That's the only way to get reliable, effective results.

When you first got your PC, like most of us, you probably were hardly able to run "the thing." As time went on, you learned how to communicate with your PC, and how it reacted to your instructions. Most of that time you worked with the PC through applications. This next section will help you learn about your hardware by actually looking at it. You'll become familiar with your PC by taking it apart.

Most of the instructions have a similar structure. First, we'll present an overview of all the necessary steps. This will give you an idea of how much time and effort is involved in a specific upgrading procedure. After the overview, we'll describe the steps needed to complete the upgrade.

Switch off the computer

Switch off and unplug the computer before you do any work within the case. This is important to the computer's survival and your survival.

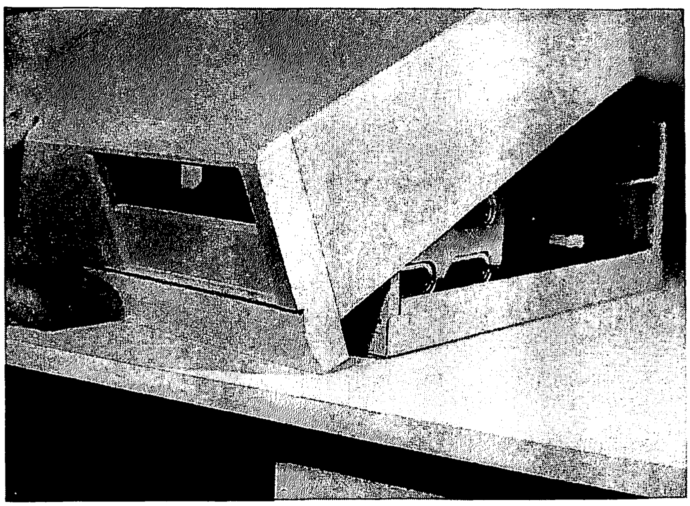
7.1 Case

We described the various types of cases in detail earlier. Now we'll discuss some hints for handling cases properly.

Opening the PC case

Regardless of the type of case (e.g., desktop case, a mini-tower case, or an upright case), there are three ways to open it.

1. Case hinged on chassis.
2. Front cover attached to chassis; top moves back and/or up.
3. Front cover attached to case (independent of chassis); top and cover pulls forward.

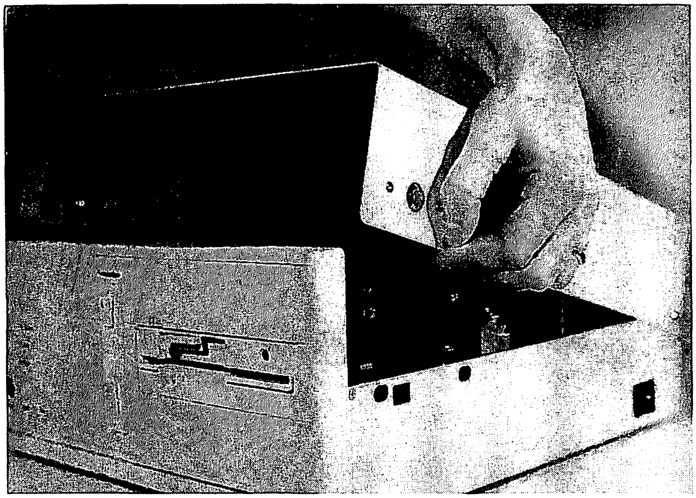


The front cover is part of the top

You can easily determine which type of PC case you have. On upright and mini-tower cases, the screws are on the back of the case. Usually there is one screw in each corner and one screw on either side in between the corner screws. Some mini-towers even have screws on the sides. Don't confuse these screws with the screws to the power supply.

Desktop cases usually also have screws on the back, with four in the corners and one halfway in between the two top corner screws.

You will also find desktop cases with screws on the sides. Some cases must be placed on their backs to get to the screws.



The front cover is part of the chassis

When you loosen the screws, move the top carefully in the proper direction. Move slowly and gently, as the brackets which hold the screws in place may catch on cables. Don't shake or drag the top of the case because doing this could cause damage.

TIP

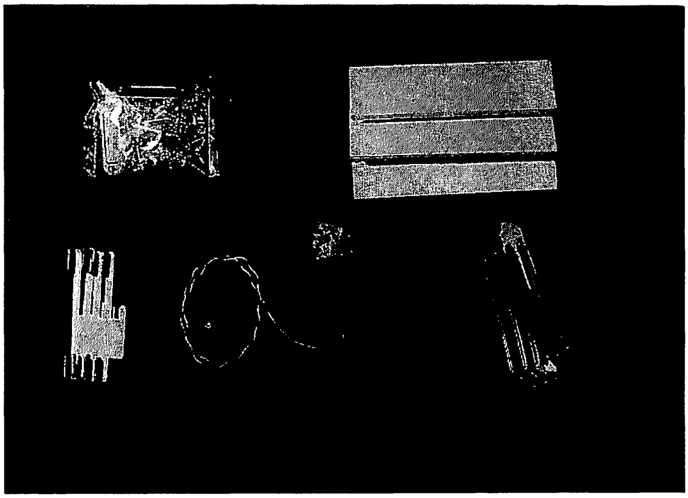
You should always be careful with desktop cases. However, be especially careful with those manufactured by Highscreen. Older 286 models frequently have internal hard drives placed to the right of the power supply. The top of the case usually gets stuck there, so you must bend it past the power supply.

If you're unpacking a brand new case from the box to build your own PC, please read Chapter 9.

Starting from scratch

For now, we'll simply say that you'll probably have to add items to the case before installing any components. New cases usually come with a package that has all the accessories you'll need to attach to the case. Sometimes you even have to attach the legs.

You won't find a set of instructions. Fortunately, you do have this book.



Case accessories

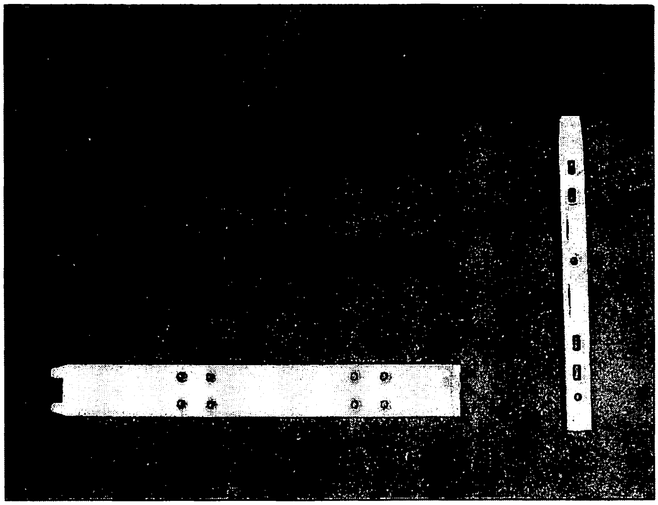
Install the speaker first (later on you might not be able to reach the area). One installation method fits the speaker into a plastic holder in the front left of the chassis. Insert the speaker's magnet (the metal cylinder at the back of the speaker) in the plastic holder in the chassis.

A second method uses magnetized clips. You'll usually find these flaps in the front left part of the case.

Mounting rails

You may find mounting rails for hard drives and disk drives among the accessories. Save these rails, because without them you will have problems installing a disk drive or hard drive.

The power switch may not be connected to the power supply. See Section 7.2 for instructions on making this connection.



Mounting rails - they're all different

If you're working with a used case, you'll have to hope that any case components that aren't attached are at least somewhere in a bag. Finding the right mounting rails may be a matter of luck. .

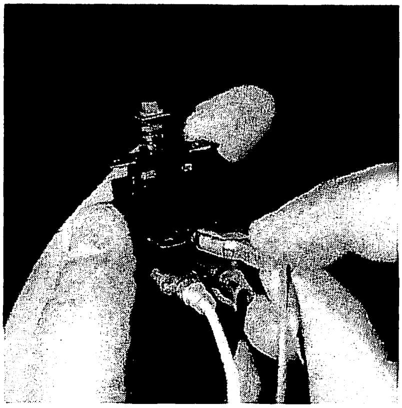
CAUTION

Never drill or file anything within the case. One mislaid metal filing or fragment can do a lot of damage if it bridges a connection on the power supply or motherboard. It's impossible to completely remove these fragments.

7.2 Power Supply

There's not much to say about the power supply. Most power supplies are self-contained (i.e., power supply and power switch built into one unit). In some cases, you must connect the power supply to the power switch by cable.

For more information, refer to any diagrams pasted to the power supply or to the documentation included with the power supply.



Connecting the power switch

Replacing the fan

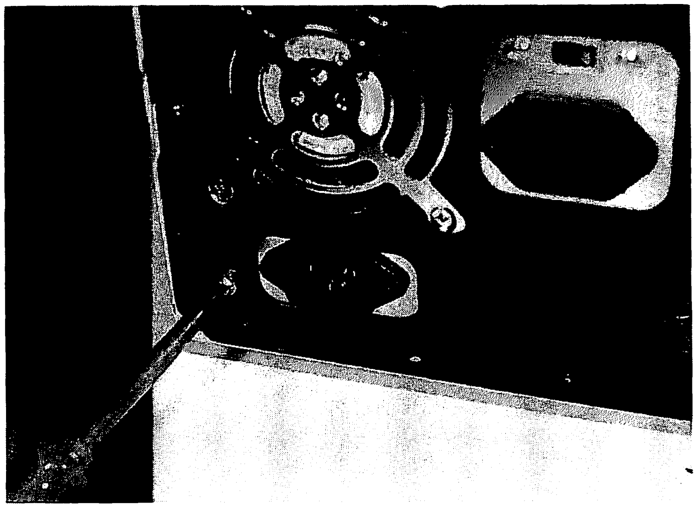
One of the few improvements you can make to the power supply is to replace the fan with a quieter model. This type of power supply fan is sometimes called a muffin fan, because its low cylindrical design looks like an English muffin.

Several manufacturers produce very quiet fans. You can also purchase a temperature-regulated fan. This upgrade should be performed only by those with steady hands; some danger is involved because you have to open the power supply to make the replacement.

STEP 1:

Remove the power supply

To make your work easier, remove the power supply from the PC. Disconnect all the cables from the motherboard, the devices, and the power supply. Then remove the four screws on the back of the case. Now you can remove the power supply from the computer.



Removing the screws from the power supply

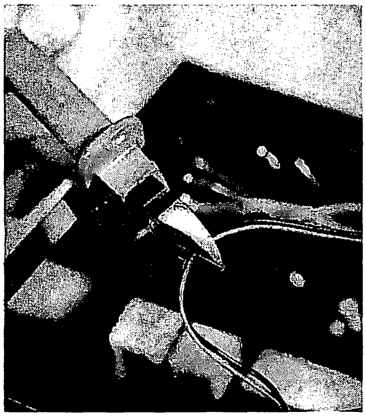
Wait about half an hour before opening the power supply, so the voltage has time to die down. Use insulated tools when you perform this work. NEVER touch the inside of the power supply.

STEP 2:

Remove the old fan

Open the power supply case and remove the four screws holding the old fan to the power supply case. You may also have to remove the grill from the fan. The fan usually gets power from a black and red two-wire cable. Generally, the red wire is the "hot" or phase line (carries the current).

After unscrewing the old fan and removing it, see where the cable ends on the power supply. There may be a connector, or you may have to cut the black and red cable. If you must cut the cable, save as much of the cable leading into the power supply as possible.



Cutting the fan cable

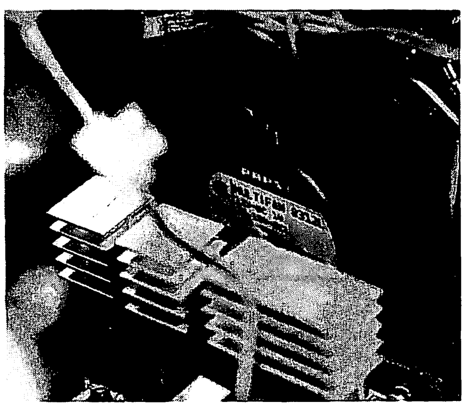
STEP 3:

Install the new fan

Attach the ends of the cables to a two-line connector that mates with the new fan's connector. Remember to connect the wires red to red and black to black.

Don't forget the fan grill

Now reattach the screws to the new fan and reattach the fan grill. Wrap some electrician's tape around the connectors, then attach the power supply case.



The installed replacement fan

STEP 4:

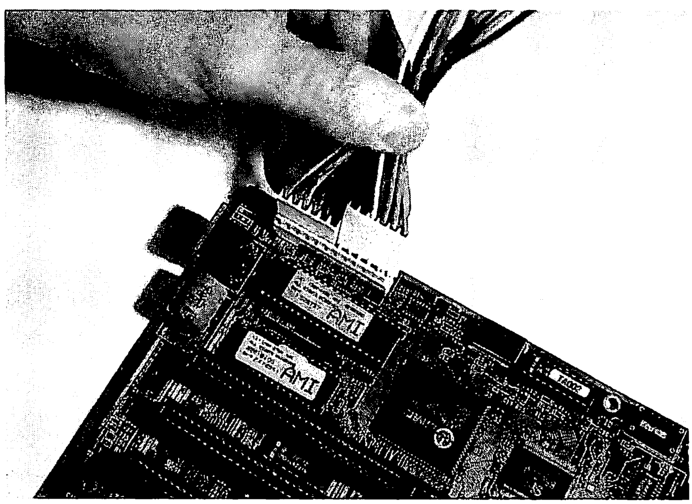
Test

Reconnect the power supply to the motherboard and the other devices. Plug in a power cable and switch on the PC. If the power supply doesn't run and only makes a soft whirring noise, you've done something wrong. Otherwise, the fan will work and the PC will run normally.

STEP 5:

Install the power supply

After that you can reinstall the power supply and screw down the back of the case.



The plug with the three red cables goes toward the inside

7.3 Disk Drive Installation

Considerations

Although installing a disk drive isn't a difficult task, there are some things you should consider. Preparation is essential. Before you decide to install a second disk drive, take a good look inside your PC case. Observe where cables start and end. Thinking everything out in advance can help avoid costly disappointments later.

Is there a space for the drive?

The most important question is whether there is room to install another disk drive. You won't have any trouble finding room in upright cases or mini-towers. Still, it's always a good idea to take a good look inside the case to ensure that the computer has enough room.

Drive mounting brackets

Generally you won't have any trouble finding room in today's desktop cases, either. These cases are designed to hold two disk drives of varying formats, and at least one hard drive.

Older desktop cases frequently have only two mounting brackets, one for the hard drive and one for the disk drive. You may also have difficulty with cases that have three mounting brackets on top of one another if the hard drive is full height. It will block two 5.25-inch mounting brackets.

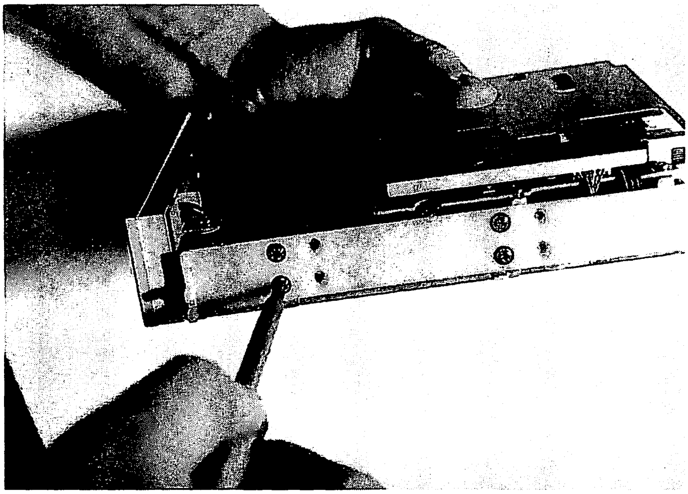
TIP

Be careful with brand name products. Manufacturers of brand name products tend to package their computers in PC cases that don't have room for a second disk drive. In those cases, you can still use an external disk drive for your second disk drive.

After ensuring that the case has enough room to install the drive, check whether you'll need mounting rails to attach the drive.

Differences between models

Check the first drive carefully. If you need mounting rails, it's a good idea to take the rails from this drive with you when you purchase rails for the second drive, since there are numerous types and models. It's also possible that the rails are screwed into one of the free drive mounts.



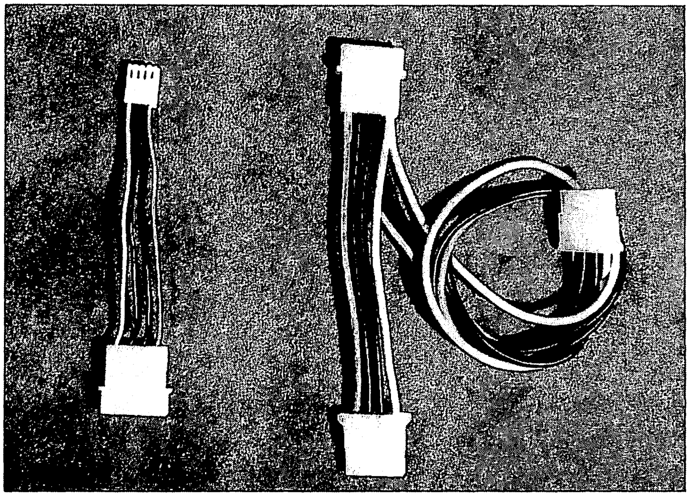
Attaching a drive with mounting rails

Is there a free power connection for the drive?

You can't always answer this question immediately with yes. To be on the safe side, check for an unused disk drive power connection. Some power supplies have very short cable harnesses, so you'll run out of room quickly. If you cannot find an unused power connection, you'll have to use a Y splitter cable. You can buy these Y cables at an electronics store.

TIP

We don't recommend homemade cables, and we suggest you avoid making any hardware changes to the existing power cables.



Y power splitter cable and adapter for 3.5-inch drives

3.5-inch adapter

Remember that some 3.5-inch disk drives have different power supply connections than 5.25-inch disk drives. You may have to buy an appropriate adapter (you can also get the adapter at the electronics shop). Modern PC power supplies have the correct connectors built in.

Brand name products?

People are constantly asking us to recommend a disk drive or tell them about quiet disk drives. In our experience, we don't know of a manufacturer's products that we could either praise or criticize. After a certain amount of use, every drive gets louder.

5.25-inch disk drive installation

We'll assume that you have a computer with an existing disk drive. The format doesn't matter. If this is not the case, skip ahead to Chapter 9. If you haven't done so, switch off the power, unplug the PC, and remove the case. Make sure you have room for the second drive.

Preparations

In keeping with our motto, "first test - then install", we'll start by connecting the drive and setting it up. Later we'll tighten the screws.

STEP 1:

Setting the drive

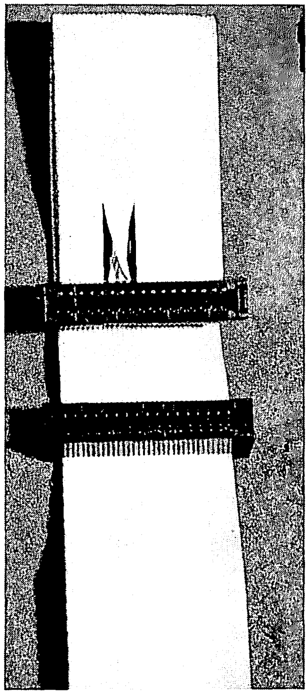
Jumpers

Generally you won't have to make any settings to the drive itself. Disk drives are preset as the second physical drive at the factory. Don't touch the jumpers on the drive, especially if you don't have any documentation for the drive. The overwhelming majority of IBM compatible PCs differentiate between the first (A:) and second (B:) disk drives through the data and controller cable, instead of a drive setting.

Twist and turn

The first drive (A:) is connected to the end of the flat ribbon cable, whose data lines 10 to 16 (calculated from the marked cable side beginning at the right) are visibly twisted. These twisted lines convert the default "Drive select" jumper 2 to 1. The controller selects the drive behind the twisted lines as the first drive.

The connection for the second disk drive, from the controller's view, is in front of the twisted lines. The cable is straight and the default "Drive select" jumper 2 is preserved.



The twisted and straight ends of the floppy cable

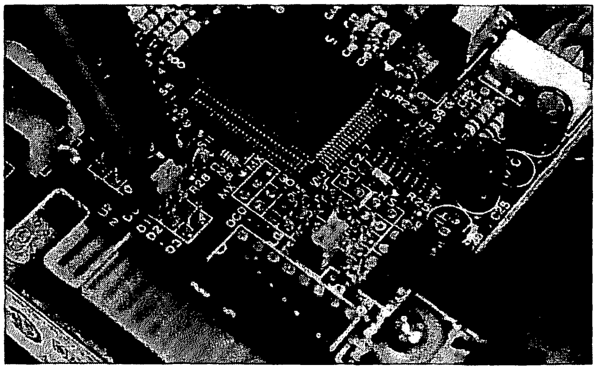
Only rarely do you find floppy cables that aren't twisted. Provided that the first drive is available and has the correct setting, you won't have any problems with the second drive, since it's preset.

Drive select

However, if you're replacing the first drive (e.g., because it is defective), you'll have to set the "Drive select" jumper on the drive. Usually there are a number of jumpers that enable settings from 0 to 3 (or 1 to 4). These jumpers are often marked "DS" for "Drive select."

Depending on where the numbers start, the "Drive select" jumper for the first drive must be set at DS0 or DS1. However, often solving the problem isn't that easy.

We recommend simply replacing the straight cable for one with a connection in front and in back of the twist.



The "Drive select" jumper on the drive

STEP 2:

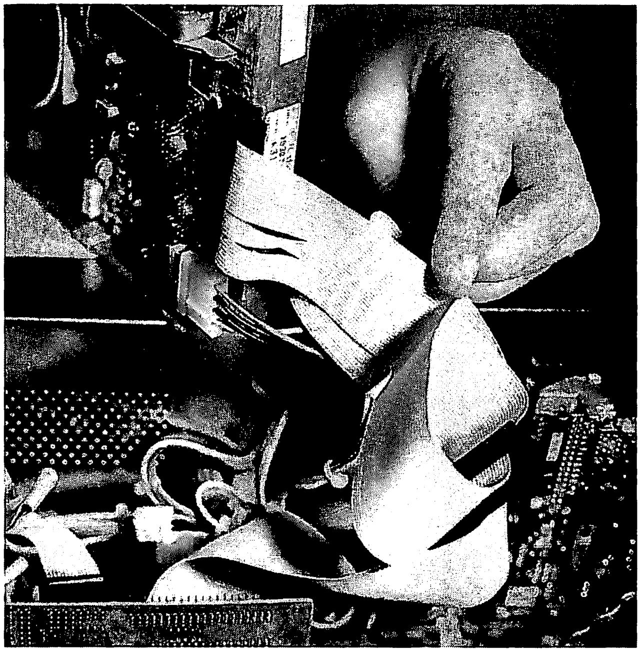
Connecting the controller and drive

First, second...

Since we're explaining how to install a second drive, the first drive is already connected with the controller card. On some computers, the cable also leads directly to the motherboard.

Usually the first drive will be connected to the twisted end of the cable, as we've described.

However, often the cable also has a second plug, which extends from the controller card in front of the cable twist. This is the connection for the second disk drive. If you don't have this second connection, or if it doesn't have the right plug, replace the entire cable for one that does.

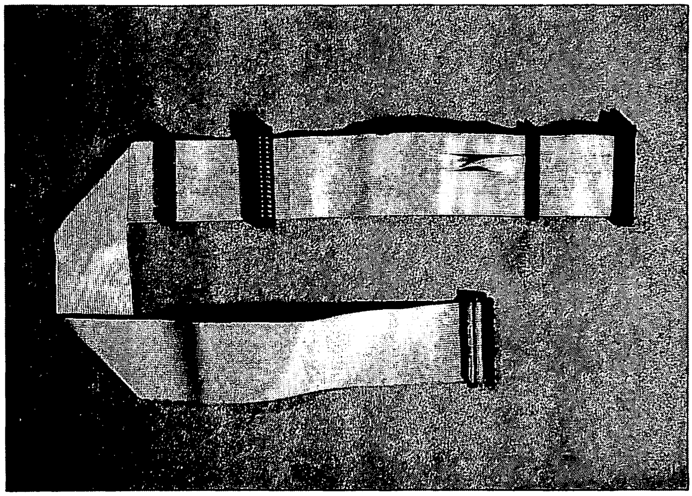


The cable connection between controller and drives

Apples and oranges

Modern PCs have two different plugs for both drives, since different plugs are required depending on the drive format. The 5.25-inch drive requires a card connector that plugs into the drive card strip so the labeled side of the cable is adjacent to the side where the card strip of the drive has a notch.

Generally, it's not even possible to twist the cable because the plug has a crosspiece that fits into this notch. If this crosspiece isn't on the labeled side of the cable, this indicates that the plug wasn't attached to the cable properly.



A universal floppy cable

Before setting the drive on any surface on the PC, we recommend that you place a non-conducting object on that surface (e.g., a book).

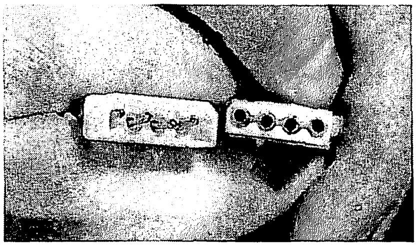
It's best to place the drive connected to the controller on its side (e.g., on the PC power supply) if the cables are long enough. For your test, simply place the drive in a position in which the head arm on the bottom of the drive can turn freely and the electronic circuitry of the drive doesn't come into contact with other metal parts.

STEP 3:

Supplying the drive with power

Round corners!

Now take a free power cable from the power supply and connect it to the power connection on the disk drive. The outlet is made of white plastic. Four contact pins connect the plug to the power line. The shape of the socket prevents you from plugging in the plug incorrectly, as long as you don't use force. Remember that two of the four corners are round.



A definite connection

STEP 4:

Setting up the drive

Setting up

As you learned in Section I, beginning with the 286 generation, every IBM compatible PC has a configuration memory called CMOS-RAM or AT-SETUP. You must set up the drive you just connected in AT-SETUP.

You can start SETUP either from the ROM of the computer or from a diskette. Today it's possible to call SETUP by pressing a key or combination of keys after the computer tests its RAM (main memory). If you aren't sure how to call the SETUP program on your PC, refer to Chapter 8. You can also get help by checking the motherboard technical documentation, or your PC's user manual.

Reassembly

Ensure that you have all the cables connected correctly and that the connected drive isn't in contact with any live parts. Now reconnect all the other cables (keyboard, monitor, power) and boot up your computer.

Next, start the SETUP program. Many BIOS implementations recognize the existing difference between the setup configuration and the new configuration themselves and prompt you to call SETUP.

In the input window for the standard CMOS, select the proper setting for drive B:. This may be "1.2 Meg," or "High Density" (1.2 Meg drive). Otherwise, use the setting "360K", "Low Density", or "Double Density" (360K drive). Which term you must enter varies depending on the manufacturer of the BIOS.

Normally you use the cursor keys to select from default values. Refer to Chapter 8 for more information. Remember to save the new entries you make.

STEP 5:

Test the drive

After connecting and setting up the drive, test it to see if it works. First, see if the PC starts up correctly. Watch the startup process carefully. After you switch on the PC, it should test RAM, briefly access the two disk drives in the proper sequence, sound a short beep (boot signal), and then load the operating system either from the hard drive or a diskette in drive A:.

2nd test

If the startup process doesn't proceed as we described (both drives are accessed simultaneously, the drive LEDs light up at the same time, etc.) or you get error messages during formatting, switch off the computer and check the cable connections between the disk drives and the controller again.

You can also refer to Chapter 11 for more information.

Format a diskette

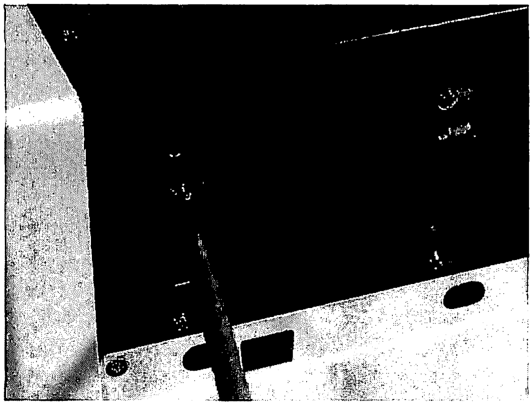
However, if startup runs smoothly, you're almost home free. You still have to format a diskette with your new disk drive. If you're able to use the DOS FORMAT B: command successfully, and the diskette formats as it should, then you know all is well with your new disk drive.

STEP 6:

Install the drive and tighten the screws

The finale

Now switch off the computer, unplug the power supply, and disconnect the cables from the drive. Install the drive in your PC case with the head arm facing the bottom or on its side (never on its back). You might have to use mounting rails. If you do use mounting rails, fasten the mounting rails with countersunk screws; otherwise you will have trouble inserting the drive.



Two screws on each side

After attaching the drive, reconnect the cables on the drive. Before closing the cover, test the drive again as described in step 5. Make sure you haven't left any screws in the computer, then tighten the screws in the case. Now you're finished installing the disk drive.

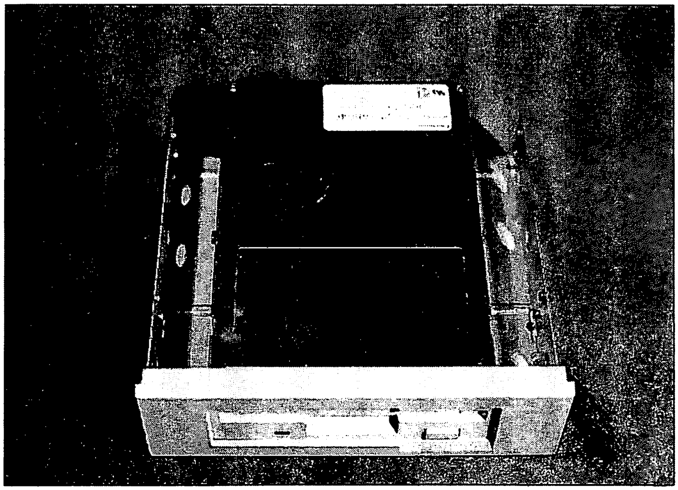
3.5-inch disk drive installation

To install a 3.5-inch disk drive with 1.44 Meg capacity, follow the procedure described in Section 7.3 for installing a 5.25-inch drive. The installation process is almost identical.

However, there are a couple of special features we'd like to mention.

Mounting kit

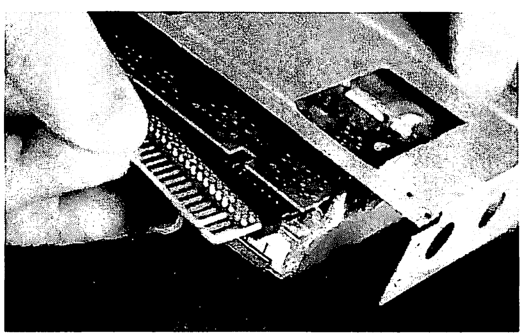
Not all cases have one or more 3.5-inch mounting brackets. If your case doesn't, you must buy a mounting kit for a 5.25-inch slide-in unit.



A disk drive in a mounting kit

Connectors Pinups

The connector on the controller cable for connecting a 3.5-inch drive has a different appearance than the card connector used for 5.25-inch drives. To connect the drive directly, you need a post connector that will accept the 34 contact pins on the drive. Line 1 (labeled side of cable) is usually on the inside, next to the power connection. In some cases (e.g., with CHINON drives), pin 1 is outside on the edge of the drive. Normally you'll be able to see labeling on the drive board (pin 1 or 2, or pin 33 or 34).



Adapter plug

You can also purchase small adapter boards that let you connect 3.5-inch drives to card connectors.

Power adapter

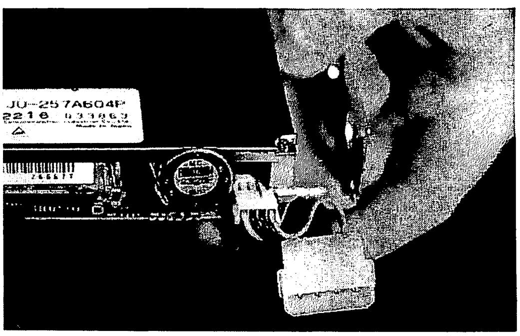
If your 3.5-inch adapter case doesn't have the 3.5-inch mounting bracket, most likely it doesn't have the proper power connection

for this kind of disk drive. The power connection for a 3.5-inch drive has a completely different appearance than the power connection for 5.25-inch disk drives. You can buy the necessary adapter at an electronics store.

The power connector isn't as clearly labeled as standard power connectors for 5.25-inch disk drives. Usually the bottom of the power connector has a small plastic object that fits in a hole in the power socket of the drive (underneath the contact pins). In any case, you should be able to plug in the power connector easily, without bending the contact pins. If the case doesn't have the 3.5-inch mounting bracket, most likely it doesn't have the proper power connection for this kind of disk drive.

CAUTION

Be careful! A faulty connection will destroy the drive.



3.5-inch drive with power adapter

DOS version

Remember that only DOS Versions 3.3 and later support 3.5-inch disk drives with 1.44 Meg capacity. You can use double-density drives at 720K capacity with DOS 3.2 and higher versions.

Combination drive installation

There isn't a difference between installing a normal disk drive and installing a combination disk drive. Combination disk drives combine a 3.5-inch disk drive with a 5.25-inch disk drive in one device.

You cannot connect a combination drive, as the second drive, to a conventional combination or disk controller that's designed to manage two disk drives. If you have such a controller, you must operate the combination disk drive as the only drive.

Space advantage

Combination drives are the same size as conventional 5.25-inch disk drives. This means that you can run both drives in a single 5.25-inch mounting frame. This is beneficial for owners of very flat PC cases, especially if they want to install other equipment, such as a CD-ROM drive.

It's very easy to install a combination drive.

STEP 1:

Set the drive

A and B or B and A or?

Combination drives are preset with the 5.25-inch drive as the first drive (A:) and the 3.5-inch drive as the second drive (B:). You can switch the two drives by changing the "Drive select" jumper. A jumper strip is in charge of the priority order for the two drives. To set the 3.5-inch drive as drive A:, set the jumper for this drive to DS1 and set the jumper for the 5.25-inch drive to DS2.

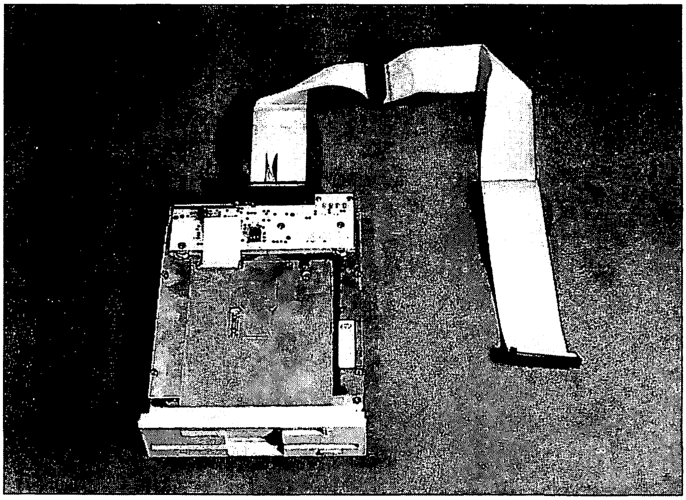
STEP 2:

Connect controller and drive

Two drives, one cable

To connect to the combination controller, you'll need a conventional 34-pin flat ribbon cable with a post connector on the controller end and a card connector on the floppy end to accept the combination drive's edge connector.

On this end, 7 of the 34 lines must be twisted, as we explained earlier. While conventional disk drives require separate connections for A: and B:, the combination drive needs only a single flat ribbon cable connection.



The combination drive on the twisted cable

Place the labeled side of the cable on Pin 1 on the controller and connect it to the combination drive using the notched side of the contact strip (as with typical 5.25-inch disk drives).

STEP 3:

Supply the drive with power

Supply the combination drive with power in the same way you would supply a conventional 5.25-inch drive with power. The combination drive requires only one power connection. The connection jack is the same one you use with a conventional 5.25-inch disk drive.

STEP 4:

Set up the drive

To set up the two drives in CMOS SETUP, follow the same procedure you would for regular disk drives. When entering the drives, use the same setting you did when selecting the "Drive Select" jumper sequence for the combination drive.

STEPS 5 AND 6:

Test the drive and tighten the screws

These two steps are identical to steps 5 & 6 described earlier in this section.

You're now finished installing the combination drive.

Four disk drives on one PC

Now that you know how to install different types of disk drives, we'll explain how to connect more than two disk drives to a PC. This procedure usually involves replacing the current disk controller. It's important to examine the hardware requirements carefully to prepare for and execute this upgrade properly. It's absolutely necessary to examine the PC case to determine exactly what kind of controller is currently being used to control the disk drives in your PC.

So unplug the power supply cable and take a good look at the inside of your PC case.

Preparation: Determining the hardware requirements

The diskette controller is located on the motherboard

No solution

Suppose that the flat ribbon cables from the disk drives lead directly to a connection on the motherboard. Your next move is to check the motherboard documentation or user manual to determine if the diskette controller (FDC) can be disabled "on board".

If it can be disabled, purchase a diskette controller that handles four disk drives and all formats. If you cannot disable the diskette controller, then to the best of our knowledge, there is no way to solve this problem.

The diskette controller is on a separate expansion board

Fast four

Suppose that the flat ribbon cable of the disk drives leads to a card in one of the expansion slots and that the card isn't combined with any other devices. In this case, purchase a diskette controller (not a combination controller) that handles four disk drives in all formats and replace the installed card with the new one.

A combination controller is managing the disk drives

Replacement

Suppose that the flat ribbon cables for disk drives and hard drives are both connected to the same expansion board. If the card still has a 34-pin connection free, you can probably connect two more disk drives there. If not, replace the combination controller completely with a similar (MFM, RLL, AT BUS, SCSI, ESDI) combination controller that can manage four disk drives.

Another option would be to disable the diskette controller part and install another diskette controller that can manage four disk drives and has all formats. The second solution makes sense when the installed controller card contains other connections (serial and parallel ports and joystick ports).

No magic solution

Now that you know the hardware requirements and how to connect up to four disk drives, we'll describe the procedure for this upgrade step by step. Because of the many controllers for four disk drives currently on the market, some controllers may not fit our description.

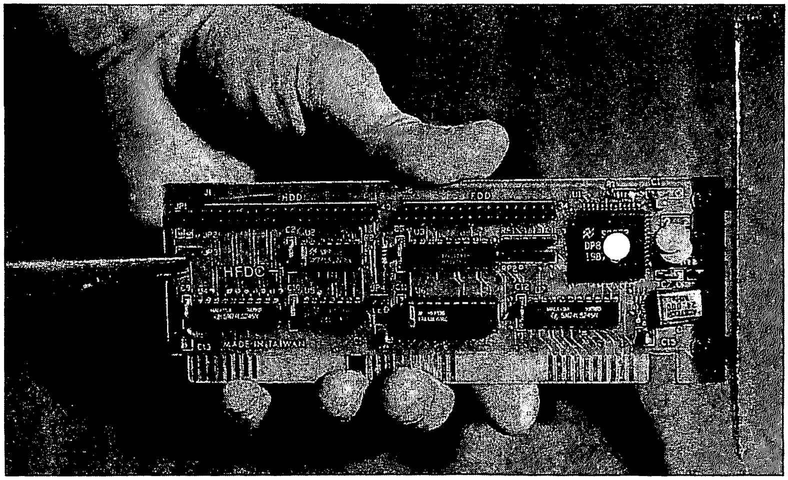
Also, be sure to check the power supply of your PC case for power connections for all the drives you plan on installing. If there aren't enough connections, you can purchase Y power splitters.

STEP 1:

Remove or disable the diskette controller

To remove the diskette controller either to replace it or simply disable it, first loosen the attachment screw to the face plate on the case. Then carefully pull up the card from the expansion socket.

To disable the controller, either reset, connect, or disconnect a jumper on the controller board or change a setting on a DIP switch. In either case, you need either the technical documentation for the controller board or a great deal of time and patience to make the correct setting.



Disabling the disk controller

STEP 2:

Install and connect replacement controller

BIOS or CONFIG

Depending on your hardware, now you must use another controller or an additional controller. Depending on the model, you must set switches or jumpers on the controller to let the controller BIOS know what kind of disk drives are connected. Set only those drives that have been connected up to this point.

With some quadruple disk controllers, you must also install software. You would then control the third and fourth disk drives using device drivers that must be entered in the CONFIG.SYS file. Refer to the controller documentation or installation guide for more information.

After making all the necessary settings, reconnect the cables of the existing disk drives (for combination controllers, reconnect the hard drive as well) first. Make sure that you connect the labeled side of the cable with the pin marked 1 on the controller connection.

STEP 3:

Plug in the computer and check the disk controller

Delays are possible

After all the cables are connected properly, first check whether the system functions as before. Reconnect the monitor and the keyboard, reconnect the PC to the power supply and boot up the system. If the entries in CMOS SETUP haven't been changed, the PC will have to access all the disk drives and boot without error messages. This process may take longer than before, since the controller BIOS also appears on the screen. Be patient.

If your PC doesn't start up as it should, try to eliminate the errors before connecting the rest of the drives. Read the controller documentation and Section I for more information.

If the PC starts up without any errors and goes to the DOS prompt, you can continue with the next step.

STEP 4:

Connect the remaining disk drives and test them

Try them out first

To do this, first switch off the PC and unplug the power supply. Then set the additional disk drives on the controller in accordance with the controller documentation or installation guide. Connect the new disk drives first and try them out before installing them physically. Use the disk controller documentation as a guide.

After all the drives are properly connected and supplied with power, reconnect the system to the power supply and start up the computer. If startup runs smoothly, format a diskette in each of the disk drives, starting with A:. See whether you can boot from a diskette in drive A:. If all of the disk drives formatted their diskettes properly, then you know everything is okay.

LASTDRIVE

However, if you're unable to address a drive, remember that DOS only defaults to five logical drive letters (A: to E:). For example, if you require six different drive letters (e.g., two hard drives and four disk drives), you must increase the maximum value for the number of logical DOS drives with the LASTDRIVE command. In our example, you must enter the line LASTDRIVE = F in the CONFIG.SYS file.

```
C:\>type config.sysd
DEVICE=C:\WINDOWS\HIMEM.SYS
device=C:\WINDOWS\EMM386.EXE noems
DEVICE=C:\D_D\D_D.SYS /F=C:\D_D_VOL.000
DOS=HIGH,umb
devicehigh=c:\dos\setver.exe
FILES=35
BUFFERS=30
SHELL=C:\DOS\COMMAND.COM C:\DOS\ /P
LASTDRIVE=M
STACKS=9,256
```

The LASTDRIVE command in CONFIG.SYS

If everything functions properly, disable the system, disconnect the power supply, and begin installing the disk drives physically. Follow the instructions earlier in this section.

7.4 Hard Drives

Installing a hard drive in an IBM compatible PC isn't as easy as it might sound in a magazine article. It's actually a complicated process that requires an understanding of the technical connections in order to be done successfully.

Normally, the differences can be tremendous, depending on what kind of hard drive you want to install. There are a number of items to keep in mind when preparing to repair a hard drive or upgrade to a new one.

Different requirements

Earlier we provided a detailed description of the various hard drive systems used with IBM compatible PCs, including their advantages and disadvantages. In this section we go into detail about installing the different hard drive systems on your computer.

Similar to any upgrading procedure, once again it's a matter of identifying the requirements first.

Preparation

Free choice

The most important consideration is determining the type of hard drive system with which you're dealing. If you don't have a hard drive controller or a hard drive in your PC, this process will be simple. You can choose from almost any hard drive system. If you decide to install a completely new hard drive system (consisting of

hard drive, cable set, and controller card), then the most important task is already complete.

Twin obligations

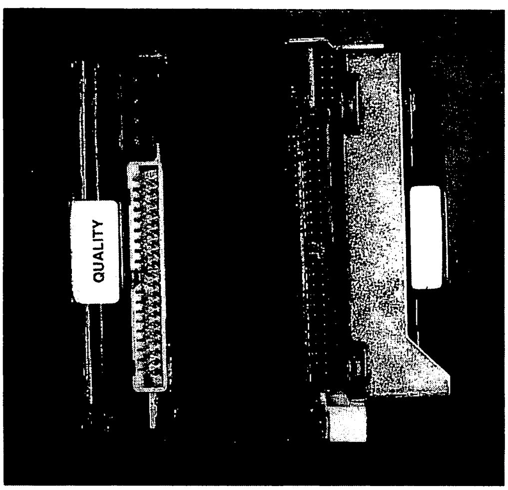
However, if your PC already has a hard drive controller, then you must buy a hard drive system that corresponds with that controller—unless you want to replace it.

This is especially true if you want to add a second hard drive to the existing hard drive/controller set. With a single exception (some RLL hard drives can also be formatted as MFM drives, at the expense of capacity), it's impossible to manage different hard drive systems from the same controller.

Identifying the existing hard drive system

If you don't know what kind of hard drive system you have, the flat ribbon cable connections can help you identify your system. The post connectors of the flat ribbon cables to the hard drives are plugged into a strip with contact pins.

If this pin strip has 40 pins and only one cable goes from the controller to the hard drive, then you have an IDE or AT bus controller. 50-pin strips indicate an SCSI controller. In both cases, the pin strips help you clearly identify the hard drive system.

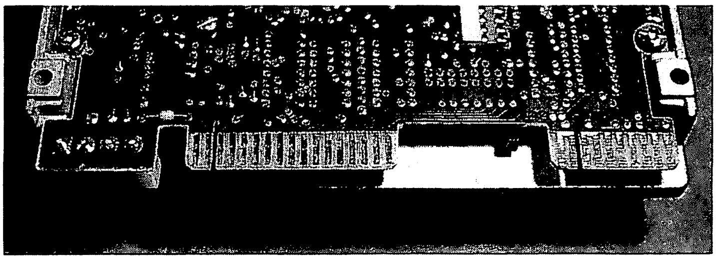


AT bus (left) and SCSI (right)

The hard drive controllers for MFM, RLL, and ESDI hard drives all have a 34-pin strip for connecting the hard drive control cable and a 20-pin strip for the data cable. So there are two cables

connecting the hard drive to the controller. You won't be able to identify the hard drive by the pin strips.

Instead, check the controller card for a possible model designation. If you have a hard drive connected, use the model designation in our hard drive list in the appendix to determine the type of hard drive system you have.



The two card connectors of an MFM/RLL hard drive

Buy the right material to mount the hard drive

Be sure to get the right kind of material for mounting the hard drive. The hard drive must be securely fastened. You should be able to place the drive in any position except upside down or slanted to one side.

Modern hard drives come in 3.5-inch format and can be installed in 3.5-inch housings in today's cases. Older desktop cases and big tower cases have only 5.25-inch mounting brackets.

The only way to install 3.5-inch hard drives into 5.25-inch mounting brackets is with the help of a mounting kit. You may also need mounting rails.

You can tell by the way the disk drives are attached. Before attempting to install a hard drive, make sure you know how you are going to mount it in the case.

The hard drive power supply

Power supplies on today's PCs are able to operate up to two hard drives. Modern PC power supplies usually supply 200 watts, which is more than enough. To be on the safe side, you should check whether your PC power supply has a free power cable to which you can connect the hard drive. If it doesn't, buy a Y power splitter to divide the power cable into two connections.

NOTE

Make a FAILSAFE diskette

When you install a hard drive, it's absolutely essential that you have a bootable system diskette in a format that your A: drive can read. This FAILSAFE diskette ensures that if something goes wrong with the hard drive, you can at least boot the computer.

Format a diskette in drive A: using the following command:

```
FORMAT A: /S
```

Copy FORMAT.EXE, FDISK.EXE, DEBUG.EXE, and CHKDSK.EXE to this diskette. It would also be helpful to copy the DOS programs XCOPY.EXE and EDLIN.EXE (or EDIT.COM and QBASIC.EXE).

MFM hard drive installation

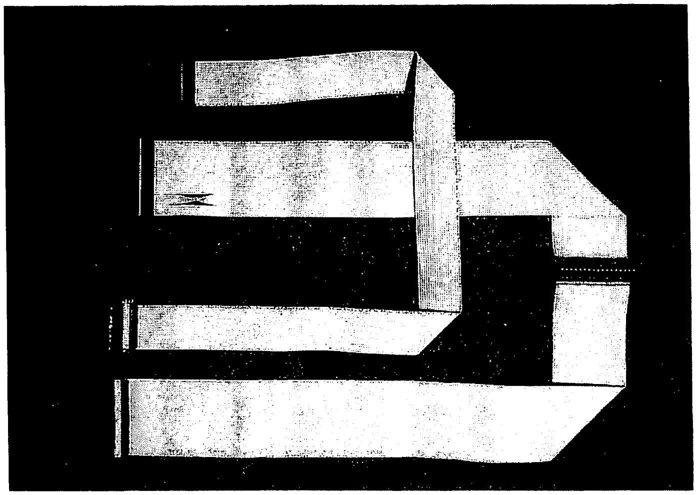
We mentioned what you'll need to install a hard drive. Now let's talk about some special features that are important for installing an MFM hard drive.

In this section, we'll assume that you have a functional MFM hard drive controller or an MFM combination controller, as well as an MFM hard drive that's in working order. We'll discuss errors that result from defective hardware in a special chapter.

The cable set for MFM hard drives

To install an MFM hard drive, you'll need a special cable set consisting of a wide control cable for one or two hard drives and one thin data cable for each hard drive.

The data cables have 20 lines with a post connector on one end that connects with the controller card and a card connector on the other end. This is connected to the smaller of the two contact strips on the hard drive.



An MFM cable set

The control cable should be equipped for two hard drives (i.e., it should have three connectors). It should have a post connector for the controller and two card connectors for either one or two hard drives. This cable is frequently twisted from line 25 to 29 (don't mix this up with the cable for disk drives, which has 7 twisted lines from 10 to 16). However, there are also cables that aren't twisted.

Special software

Help from the storage medium

As we explained in Section I, before an operating system can accept an MFM hard drive, the drive must undergo an initialization process. This process is also referred to as a low-level format. To do this, you'll need special software that isn't found in your operating system.

Software for making this low-level format is available. Some newer PC BIOS configurations (e.g., from AMI) frequently contain a program, called a hard drive formatter, that you can start from ROM. If you don't have such a utility, you won't be able to install an MFM hard drive. We'll explain how to use this kind of utility later.

Hard drive installation in eight steps

We broke down our instructions for installing an MFM hard drive into eight steps. We recommend reading through all the steps first, to get an idea of what's in store for you. We assume that you're installing the first and only MFM hard drive in your PC.

We'll discuss installing a second MFM hard drive in a special section at the end of the chapter.

The steps:

1. Set the "Drive Select" jumper on the hard drive
2. Connect the hard drive to the controller and the power supply
3. Set up the hard drive in CMOS SETUP
4. Low-level format
5. Partition the hard drive
6. Format the hard drive
7. Test the hard drive
8. Physically install the hard drive in the PC case

Let's begin with the first step. We assume that the case is already open and the power cable is unplugged from the PC.

STEP 1:

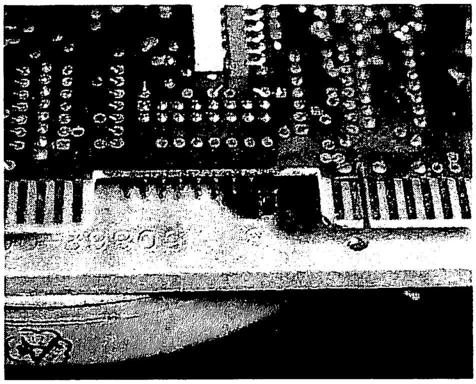
Set the "Drive Select" jumper on the hard drive

Unlike disk drives, MFM hard drives are usually preset at the factory as the first drive. The "Drive Select" jumper is set to drive "0". Generally you won't need to change the default setting on the drive.

Or the other way

A few manufacturers set their drives as drive "1". In this case, use the twisted end of the control cable instead of the other end. The straight end is free.

If your hard drive cable is straight all the way through, then you can only use it with hard drives set as the first drive, whose "Drive Select" jumper is set to "0". So you may have to change the default setting of the hard drive or else get a different cable.



"Drive Select" jumper set to "0"

Finding the jumper

Set the "Drive Select" jumper for MFM hard drives from jumpers or DIP switches. The location of these jumpers or switches on the hard drive varies for each manufacturer. Therefore, we can't provide a general description.

Seagate, the leading manufacturer, usually places the "Drive Select" jumper for MFM hard drives between the contact strips for the cable connections. If you put a Seagate drive on the table with the board on top and look from the connection strips towards the control lamp, the "Drive Select" jumper is set to "0" when the jumper is all the way to the right. If the jumper is on the second contact from the right, it means "Drive Select" jumper "1" is active. At any rate, the jumper has to be connected; otherwise it's impossible to address the drive.

STEP 2:

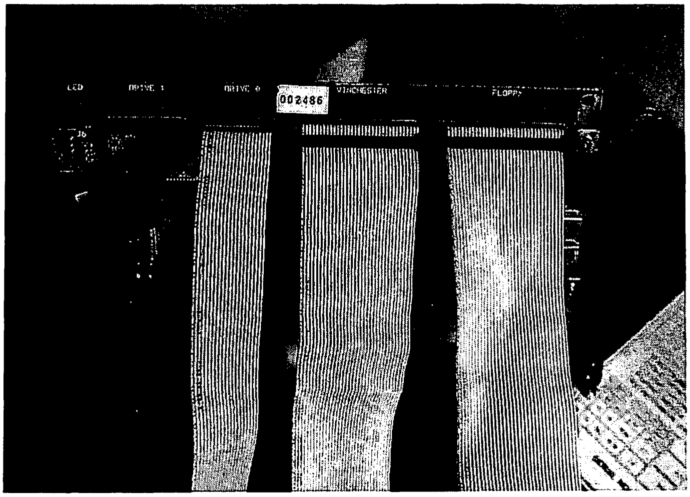
Connect the hard drive to the controller and the power supply

Find the connection

First use the post connector to connect the 34-pin control cable to the hard drive/combination controller. It's easy to find the connection on pure hard drive controllers, since there is only one 34-pin connection.

MFM combination controllers have two 34-pin connections. If the connections aren't labeled, you can assume that the connection closest to the cover plate is for the disk drives. This means that you connect the hard drive control cable to the other, inner connection.

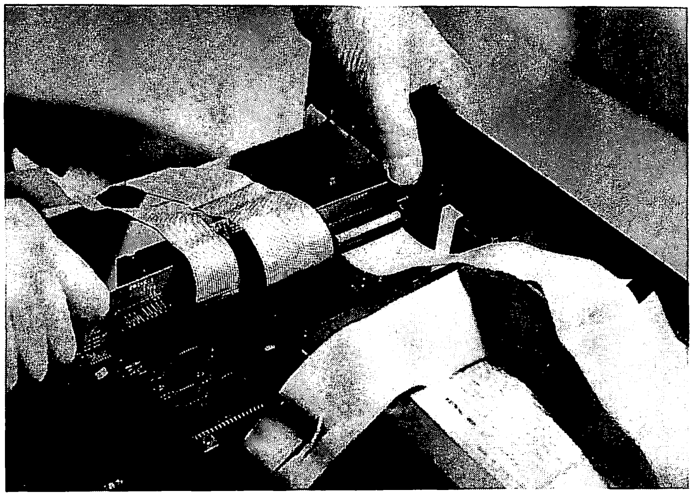
Remember that the labeled side of the cable connects with pin 1 of the connector. Generally, pin 1 or 2 or else pin 33 or 34 are labeled on the controller card. If they aren't, look at the connector from the back side of the controller board. Pin 1 usually has a square soldered joint instead of a round one.



Connecting the cables to the controller

Next, connect the 20-pin data cable to the controller. The connector is usually to the immediate left of the control cable connector. Farther left or underneath is the connector for the second data cable (important only if you use two hard drives). Connect the labeled side of this cable with pin 1 also.

Then plug the controller into any free 16-bit slot on the motherboard, as close as possible to the hard drive, and fasten the card to the back of the case with a screw. Ensure that you insert the card properly.



Using the combination controller

Danger—short circuit

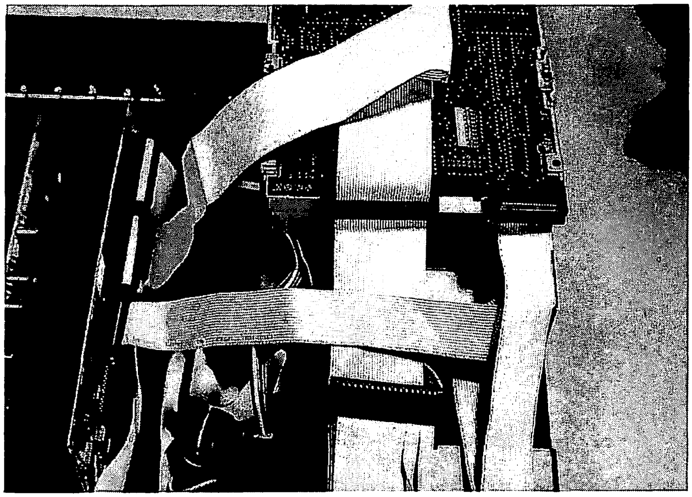
Then connect the hard drive to a free power cable from the power supply. First, place the hard drive on the PC power supply (if possible, place a non-conducting pad on the power supply, then place the hard drive on top of the pad).

CAUTION

Never force the plug in the socket

Pay attention to the shape of the plug and the socket. Never force the plug in the socket. Remember not to block the fan, and avoid short circuits on the bottom of the hard drive.

After that, connect the power and data cables to the hard drive so the labeled side of the cables adjoins the grooved sides of the contact strips. Usually the card connectors of the cables have small cross-pieces that fit into the groove so you can't plug them in the wrong way.



The hard drive is connected

Check once more whether all the cable connections are correct.

STEP 3:

Set up the hard drive in CMOS SETUP

Before you can continue with the next steps, you must tell the PC that you've added a hard drive.

All IBM compatible 286 and higher systems save their configuration in a special battery/accumulator backed memory, called CMOS RAM. The hard drive is entered in a kind of configuration list there. Every time you start up the system, the PC checks whether this list matches the hardware it finds in its self-test. If something is missing or if there are too many entries, the PC will notice and prompt you to check the entries.

Start the SETUP program to make changes to this configuration list. However, before turning your PC back on, read the rest of this section.

Many PC BIOS configurations allow you to start SETUP by pressing a key during the self-test. For example, after testing RAM, AMI BIOS displays the following message:

```
Press Del to run SETUP
```

When you press Del, the PC then branches to a selection menu from which you can start CMOS SETUP or standard CMOS.

Some of the very old 286s let you start the SETUP program only from a special diskette supplied with the computer. In those cases, you must first boot the computer from a DOS diskette (use the FAILSAFE diskette mentioned earlier in this section) before calling the SETUP program.

Strange noises

When you switch the PC back on, you will notice a change in the configuration. This change causes the computer to try to access the hard drive after the self-test. This process can last up to a minute and will be accompanied by some strange noises from the hard drive.

However, the PC cannot access the hard drive since it hasn't yet been set up. So the PC displays an error message that refers either to the controller, the drive, or the entry in SETUP. Here are some examples (each BIOS uses different error messages):

```
HDD Controller Failure

C:Drive Error

Configuration Error
```

Often the error message prompts the user to run the SETUP program:

```
Run Setup Utility
```

Frequently pressing the F1 key runs the SETUP program:

```
Press F1 to run Setup
```

Now reconnect your PC to the power supply, plug the monitor and keyboard back in, and switch on the computer. Study the monitor and follow the instructions, or try to start SETUP.

When you start SETUP, the monitor displays either dialog boxes or selection menus that enable you to enter the date, time, type of disk drives, type of hard drives, kind of graphics adapter, and other items. Ordinarily, you won't be able to type anything, but

you can select from a number of options. A status line often indicates how to make the selections.

Search and enter

Normally you'll use the cursor keys to move the cursor to a text box for the hard drive and select from a number of different hard drive types using the PgDn key. Which hard drive type you select depends on the entries for cylinders and heads that go with this type. See the list of hard drives in the Appendix for the parameters of the hard drive you're installing.

Some PC BIOS configurations (especially older ones) display the current numbers of the hard drive types, but not their drive parameters. Ordinarily in such cases you can press a special key (F1 or ?) to display a type list.

You must select the right type and enter it. This means that you must select the type whose cylinders, heads, and sectors match those of the hard drive you're installing. For example, the Seagate ST-251 40 Meg hard drive requires an entry of 820 cylinders, 6 heads, and 17 sectors. Remember that each BIOS assigns different type numbers for these parameters.

When you cannot set the drive type that you are installing...

Although this may be annoying at first, the situation isn't hopeless. Modern PC BIOS configurations offer a "User Type" under type 47. This means that you can enter the parameters yourself under this type. The entries for cylinders, heads, and sectors (always 17 for MFM drives) are important. You can set all the other values to "0" if you don't know what they are. Don't be surprised if the memory size calculated from the entries is different from the value you expected. It doesn't mean anything.

Lower capacity

If CMOS SETUP doesn't offer a User Type either, you still have the option of setting a type with lower values than the actual values of your hard drive. If possible, choose a type that has the same number of heads as the hard drive you're installing. Although this method doesn't always work with every drive, it's better than nothing.

However, using this method will cost you a couple of megabytes in memory capacity (we explained how to calculate memory capacity from the number of cylinders and heads in Section I).

Software solutions

Special utility programs for hard drive installation also give you the option of generating software drivers that manage the hard drive independently of the system BIOS. This is your last chance

to set up a "difficult" hard drive. We'll discuss this in a special chapter on utility programs.

WARNING

Never enter more cylinders or heads than your hard drive really has. If you do, low-level formatting may destroy your hard drive. Make sure you find out the correct parameters for the hard drive you are installing.

Leave the entry for the second hard drive at "NOT INSTALLED" or "NONE".

After you finish entering the parameters for your hard drive, you must save them; otherwise they won't go into effect. Usually the monitor displays information on saving. There are always two ways to exit the dialog box for CMOS SETUP: By saving and by canceling. When you exit by saving, it reboots the system, since the entries don't go into effect until the system is reset.

Confirm

When you start a PC BIOS from ROM, a confirmation prompt often appears before you save. You can answer this prompt with "Y" for Yes or "N" for No. Usually you also have to press Enter to confirm your choice. You are now finished setting up your hard drive.

Take it from the top

The screen of your PC will then clear and the computer will reboot, starting with the RAM test. Be sure to have a bootable DOS diskette in the A: drive so you can load the operating system after the autoboot routine.

During the routine, however, you'll still get an error message about the hard drive or the controller, although you made the right entries in CMOS SETUP. You may see one of the following error messages:

```
C:Drive Error
```

```
HDD Controller Failure
```

or

```
Initialization Error Hard Drive 0
```

The message simply tells you that the PC found a hard drive, but it cannot recognize it yet, since it hasn't been initialized (i.e., low-level formatted). That's our next step.

This error message gives you another opportunity to branch to standard CMOS or boot the PC. This time, boot the PC. Follow the instructions on the screen. The system will then try to load the operating system from the diskette in drive A:. If the operating system loads successfully, you can begin low-level formatting.

STEP 4:

Low-level format

After cabling your hard drive and setting the correct values for formatting the hard drive cylinders and heads in the system BIOS, you're ready for low-level formatting.

More modern personal computers, especially the ones equipped with a BIOS from AMERICAN MEGATRENDS (AMI), offer a hard drive utility as part of a diagnostic program. Like SETUP, you can also start this program from ROM. The program is actually designed to test the different hardware components. Usually you call this program like the SETUP program by pressing Del after the RAM test. Watch for screen messages; usually you can select a hard drive utility from a menu item called "DIAGS".

Because there are so many different ROM BIOS routines for low-level formatting, we won't be able to provide instructions that will apply to every case.

Formatting programs included in the package

Brand name manufacturers sometimes include diskettes containing such hard drive formatting programs. Frequently, you'll also find such programs included as part of the supplied DOS licenses. For example, a DOS supplied by Zenith often contains a program called PREP. Such programs for hard drive initialization often have extensive test routines for surface analysis of the hard drives to be formatted. Depending on the size of the hard drive, such programs can easily take several hours. For more information, see the appropriate user manual.

If you don't have one of these low-level formatting programs, then you must buy your own software. Please see the related information later in this section.

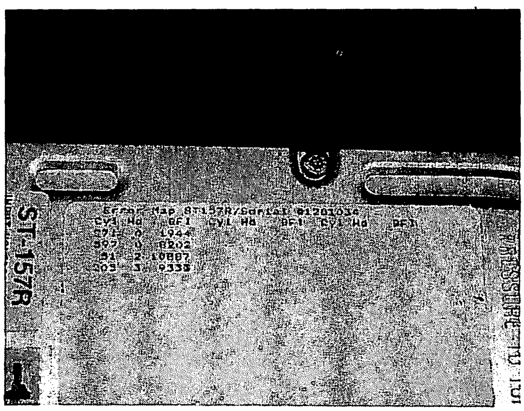
Setting the interleave

Normally, these utilities read out the hard drive parameters from the CMOS RAM and provide the low-level formatting routine. Then all you have to do is confirm the routine (usually by pressing Enter). In addition, you'll also be prompted for information about the interleave factor. If you are not certain which value to specify, refer to the explanations about the interleave factor in Section I. You'll find enough information there to help you make the necessary decision.

When the drive has defects

Finally, the utility gives you the option of making entries in the "Bad Track Table." This table provides a list of the sectors marked as defective by the manufacturer. Usually this is a list with cylinder and head numbers that comes with the hard drive.

It's a good idea to enter these bad sectors in the "Bad Track Table," since this prevents the computer from using these sectors for data reception. Hardly any MFM hard drive comes from the manufacturer completely free of defects. So don't worry if you have 10 or 20 bad sectors on your hard drive. This is normal.



The "Bad Track Table"

Caution - data loss

After you enter all the information related to the low-level format, the program displays a confirmation prompt and informs you that low-level formatting will irretrievably destroy all the data on the hard drive. Answer the prompt by pressing Y.

If all the information is correct and the hardware components are working, the utility will start counting the cylinders and heads in sequence. Depending on the hard drive model, it will make a ticking noise. When the program is finished, it displays a message on the screen, such as "Format Complete" or "Format successful."

This concludes low-level formatting. When you reboot the PC, it won't display any more error messages about the hard drive or the controller.

STEP 5:

Partition the hard drive

The hardware accepts the hard drive formatting. However, the operating system won't recognize the hard drive until it finds a partition table with information about the size and division of the storage medium. To create this partition table, use the DOS FDISK program.

Partitioning with FDISK

First, start the operating system from a diskette in drive A: and then call FDISK from the diskette.

```
                    MS-DOS Version 5.00
                  Fixed Disk Setup Program
           (C)Copyright Microsoft Corp. 1983 - 1991
                       FDISK Options


Current fixed disk drive: 1
Choose one of the following:
1. Create DOS partition or Logical DOS Drive
2. Set active partition
3. Delete partition or Logical DOS Drive
4. Display partition information
5. Change current fixed disk drive

Enter choice: [1]


Press Esc to exit FDISK
```

The DOS 5.0 FDISK main menu

You'll use FDISK differently depending on the version of DOS you have. Basically, the partition table is always created by the FDISK program of the DOS version you're going to install.

Different partitions

Since MS-DOS 4.0, DOS has been able to manage hard drives of up to 1000 Meg (or 1 gigabyte) in a single partition. That means that you don't have to divide the hard drive into several partitions, or logical drives. If you don't want to work with different operating systems on the hard drive you're partitioning, it's generally a bad idea to set up several logical drives. This also makes using FDISK easier.

```
                        Create Primary DOS Partition

Current fixed disk drive: 1

Do you wish to use the maximum available size for a Primary DOS Partition
and make the partition active (Y/N).....................? [Y]









Press Esc to return to FDISK Options
```

Create the primary DOS partition first

Make your partition active!

After calling FDISK, you see a selection menu on the screen. The first option in this menu is called "Create a DOS partition or logical DOS drive." After selecting this option, another screen appears where the first option allows you to "Create Primary DOS Partition."

Select the first option from this screen also. FDISK then asks you whether you want to use the maximum available size for the primary DOS partition and make this partition active. Answer this prompt with Y.

FDISK then prompts you to insert a bootable disk and press any key. After you do this, the computer reboots to create the partition table.

C:> returns

The PC starts up in the usual way. You shouldn't see any error messages. After you reload the operating system from diskette, DOS recognizes the hard drive.

You can access the hard drive by entering C:. DOS changes to the hard drive. You're finished partitioning the hard drive. You can now continue with step 6, formatting the hard drive.

If you have problems

However, if DOS displays the error message:

```
Invalid Drive Letter
```

this means that nothing is entered in the partition table.

Any errors made during the low-level format will show up here, at the very latest. Try to run FDISK again. If your second effort fails, retrace your steps and perform another low-level format if necessary.

Installing several partitions...

Partition size in megabytes

You can divide the hard drive into several logical DOS drives. Generally you set up the primary DOS partition first. In this case, you would answer the question about using the maximum available size for a primary DOS partition with N.

FDISK then asks you how much space you want to reserve for the primary partition, at the same time displaying the total available space.

Starting with DOS 4.0, you can specify the partition size in megabytes or as a percentage of the total capacity.

```
                    Create Primary DOS Partition



Current fixed disk drive: 1

Partition  Status   Type    Volume Label  Mbytes   System    Usage
C: 1          A    PRI DOS  PRI DOS           32   FAT16       78%
   2               EXT DOS                     9               22%
```

Determining the size of the partition

Setting up logical drives

After the message "Primary DOS Partition created" appears on the screen, press (Esc) to return to the FDISK main menu. Now set up your extended DOS partition on the rest of the hard drive. FDISK supplies the corresponding values; all you have to do is confirm them.

```
          Create Primary DOS Partition or Logical DOS Drive

   Current fixed disk drive: 1

   Choose one of the following:

   1. Create Primary DOS Partition
   2. Create Extended DOS Partition
   3. Create Logical DOS Drive(s) in the Extended DOS Partition



   Enter choice: [1]



       Press Esc to return to FDISK Options
```

Select 2 to create an extended DOS partition

FDISK then begins setting up the logical DOS drives until the entire space in the extended DOS partition has been assigned logical drives. You can choose either megabytes or percentages of the extended DOS partition.

```
          Create Primary DOS Partition or Logical DOS Drive

   Current fixed disk drive: 1

   Partition  Status   Type    Volume Label  Mbytes   System   Usage
   C: 1          A    PRI DOS   PRI DOS         32    FAT16      78%
       2              EXT DOS                    9               22%








   Extended DOS Partition already exists.

   Press Esc to continue
```

Extended DOS partition created

```
                Create Primary DOS Partition or Logical DOS Drive

   Current fixed disk drive: 1

   Choose one of the following:

   1. Create Primary DOS Partition
   2. Create Extended DOS Partition
   3. Create Logical DOS Drive(s) in the Extended DOS Partition



   Enter choice: [1]



   Press Esc to return to FDISK Options
```

Defining logical drives

Don't forget to make the partition active

After assigning logical DOS drives to the entire space, press Esc to return to the FDISK main menu. Set the active partition by selecting option 2 in the FDISK main menu "Set active partition."

NOTE

Important! The primary partition must be active. Set the primary partition so you can start the PC from there; otherwise you won't be able to load the operating system from the hard drive.

```
                          Set Active Partition

  Current fixed disk drive: 1

  Partition  Status   Type    Volume Label  Mbytes   System   Usage
  C: 1          A     PRI DOS  PRI DOS         32    FAT16      78%
     2                EXT DOS                   9               22%




  The only startable partition on Drive 1 is already set active.

  Press Esc to continue
```

The primary partition must be active

Press Esc to return to the main menu. Select item 4 to display the partition table. If you like what FDISK shows you, press Esc to exit FDISK and warm boot the computer. This makes the partitioning active.

If you want to work with different operating systems...

To work with different operating systems, partition only the part of the hard drive that you want to use for DOS. Use the partitioning programs of the other operating systems to partition the other parts of the hard drive. However, remember that only one operating system can be the active, or boot partition.

STEP 6:

Format the hard drive

For hard drive to receive data, it must be formatted, just like a diskette. In other words, you must give the hard drive a structure that DOS can read. The DOS FORMAT program performs this task. This program should also be on the diskette in drive A:.

Transferring the system files

Change back to drive A: and start FORMAT. When you format, remember to copy the system files so the hard drive will be able to boot the system and the command interpreter of the operating system can be loaded from the hard drive.

Use the following DOS command:

```
FORMAT C:/S
```

After formatting, DOS displays the formatted capacity of the hard drive on the monitor. This completes the process of formatting the hard drive.

If you set up several partitions...

You cannot boot from logical drives

If you set up more than one partition with FDISK in step 5, then you have logical DOS drives. You must also format these drives. You will have to run FORMAT for each logical drive:

```
FORMAT D:
FORMAT E:
etc.
```

Since the operating system is written to the boot sector of the hard drive and is always located in the primary partition, /s doesn't have to be added to the Format command.

You can display the current division of your hard drive at any time. To do this, choose menu option 4 "Display Partition Information" in the main menu of FDISK.

```
                    Display Partition Information
Current fixed disk drive: 1

Partition  Status   Type    Volume Label  Mbytes   System   Usage
C:  1        A     PRI DOS   PRI DOS        32    FAT16      78%
    2              EXT DOS                   9               22%


Total disk space is   41 Mbytes (1 Mbyte = 1048576 bytes)


The Extended DOS Partition contains Logical DOS Drives.
Do you want to display the logical drive information (Y/N)......?[Y]



Press Esc to return to FDISK Options
```

Displayed partition information

STEP 7:

Test the hard drive

After formatting the hard drive and copying the system files to it, you should be able to boot the PC from the hard drive.

This is the first, most important test for your newly installed hard drive. Remove the DOS diskette from drive A: and execute a warm boot by pressing Ctrl+Alt+Del simultaneously.

Does the PC start up all the way to the system prompt? If it does, then switch off the PC. Wait a couple seconds until the hard drive is quiet, then switch the system back on.

Does the PC start up now and go all the way to the system prompt without any errors?

Now see whether you can copy to the hard drive. Create a DOS directory and copy the DOS files from the system diskettes to the directory. Then try to start DOS programs, such as CHKDSK, from the hard drive.

If everything runs smoothly, then you've successfully installed the hard drive. If it runs according to your expectations, you can install it in its mounting kit.

Switch off the PC, unplug the power cable from the computer, and wait for the hard drive to stop. Then begin physically installing the hard drive.

STEP 8:

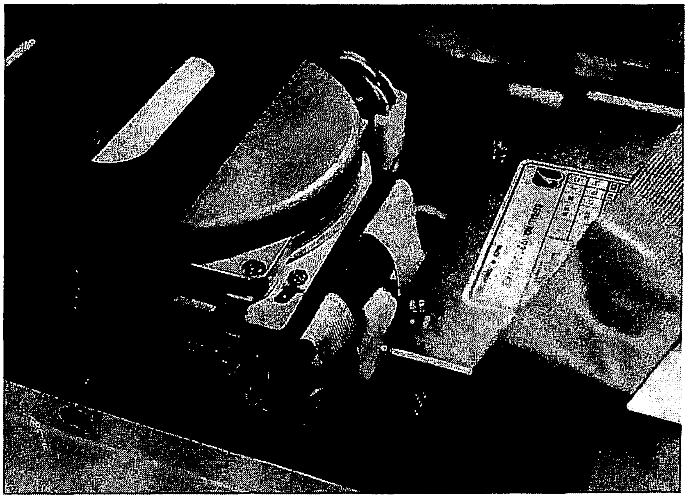
Physically install the hard drive in the PC case

Before disconnecting the cables, take another look at how they connect to the hard drive.

No angles

Now install the hard drive in its designated place in the PC case. Avoid any contact between the hard drive circuitry and any metal or other conductors of electricity.

Install the hard drive firmly and securely, be sure that the hard drive isn't tilted at an angle, regardless of whether you use a mounting kit.



The hard drive is installed

Now reconnect all the cables and try out the hard drive again before closing the PC case. Testing the hard drive again is worth all the trouble.

If you've overlooked something, you'll have to open the PC case again. So close the case and tighten the screws only when you're absolutely certain that everything is 100% okay. This completes the installation of the MFM hard drive.

Installing a second hard drive

If you want to install two hard drives at the same time, or if you're adding a second hard drive to an MFM hard drive, the most critical points have to do with setting the "Drive Select" jumper and the cable connections.

In general, the following rules apply:

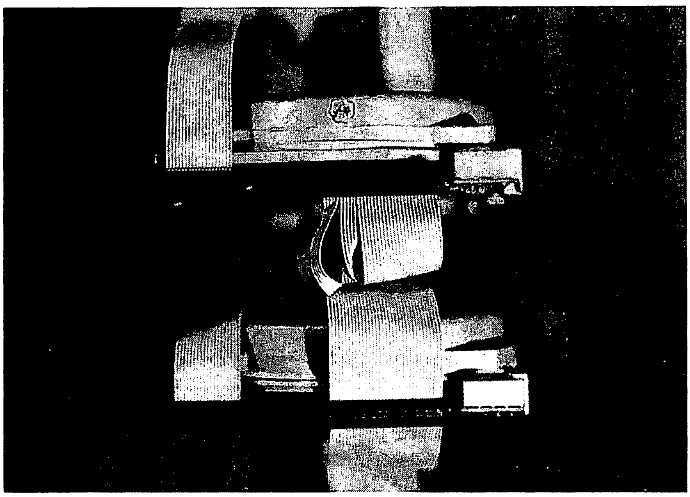
If the hard drives are connected to the controller by a 34-pin control cable that has a straight end and a twisted end, set the "Drive Select" jumper to the same position on both drives.

If the "Drive Select" jumper is inserted in the first logical position (position 0 or 1), then connect the first drive to the straight end of the cable and the second drive to the twisted end.

If the jumper is in the second logical position (1 or 2), then the first drive connects to the twisted end and the second drive connects to the straight end.

If the drives are connected to a control cable with two straight cable ends, set the "Drive Select" jumper to the first position (0 or 1) on the first drive and set it to the second position (1 or 2) on the second drive.

It doesn't matter to which plug the first hard drive is connected.



Connecting the second hard drive to the twisted cable

Mark the first and second drive according to this rule and make the connection to the 34-pin control cable. Then connect the 20-pin data cable of the first hard drive to the connector on the controller closest to the control cable connector. Then connect the 20-pin data cable of the second hard drive to the free connector.

First test

After that, enter both hard drives in the CMOS RAM. Enter the first hard drive under drive C:, and enter the second hard drive under drive D:.

If one of the two drives is already completely installed, test whether you can still boot from the first hard drive after connecting and setting up the second hard drive. If you can, then both drives are probably cabled correctly.

Caution: Data loss

Perform a low-level format as described in step 4. Remember to select the second hard drive; otherwise you'll lose all the data on the first hard drive.

FDISK also recognizes the existence of a second hard drive and offers another option. Option 5 makes it possible to direct FDISK activities to the first or second drive.

Use the FORMAT D: command to format the second hard drive. Since you can only boot the PC from C:, you cannot make the second hard drive bootable. This means that you don't have to specify the parameter "/s" when you type FORMAT.

TIP

When you physically install the second hard drive, be careful not to mix up the cables. This can happen more quickly than you think. It never hurts to take a second look.

RLL hard drive installation

Refer to the first part of this section for information about preparing to install. The preparations for installing an MFM hard drive are almost identical for installing RLL hard drives.

Since RLL hard drives are able to accept higher data densities, they are a little more sensitive to changes in temperature.

Therefore, when you install an RLL hard drive, make sure it is warm from running. Connect it to the PC power supply and let it run for about 30 minutes. Then read this section so you'll know what's in store for you.

Some differences

Installation procedures for MFM and RLL hard drives are similar in many ways. In this section we'll concentrate on showing and explaining the differences involved in installing RLL hard drives.

To avoid repetition, we'll refer to our explanations listed earlier in this section whenever appropriate.

We have also divided the instructions for installing RLL hard drives into steps. Here is an overview of those steps.

Hard drive installation in 9 steps:

1. Set the "Drive Select" jumper on the hard drive
2. Connect the hard drive to the controller and the power supply
3. The controller has its own BIOS
4. Set up the hard drive
5. Low-level format
6. Partition the hard drive
7. Format the hard drive
8. Test the hard drive
9. Physically install the hard drive in the PC case

STEPS 1 AND 2:
"Drive Select" jumper and cable connections

There are no differences in setting the "Drive Select" jumper or in making the cable connections between the hard drive and the controller.

Connect the cables exactly as you would with an MFM hard drive. The data and control cables are identical, and you supply the drive with power in the same way.

Regarding the controller, remember that you're installing an RLL controller (i.e., a controller that's capable of writing hard drives with 26 sectors per track). As you'll see in the next step, there are major differences in the controllers of the two hard drives (MFM vs. RLL).

STEP 3:
Answering the controller-BIOS

This step isn't a part of MFM hard drive installation. For MFM installation, you simply must enter the proper drive type in the

CMOS of the computer. However, for an RLL hard drive system, you must consider a few points.

The controller has its own BIOS

RLL hard drive controllers come with their own BIOS or without a BIOS. If you're using a controller that doesn't have its own BIOS, enter the hard drive parameters in CMOS SETUP, as you would with an MFM hard drive. However, if the controller does have a BIOS, you must enter the hard drive parameters there.

First, determine which kind of RLL hard drive controller you have. If the hard drive and controller are cabled correctly, reconnect the PC to the monitor, keyboard, and power supply. Insert a bootable diskette into drive A: and switch on the PC.

Since you've just connected a hard drive that is unknown to your PC, the PC BIOS will produce an error message at first, indicating a hard drive or controller error. We presented a few possible error messages earlier in this section. Don't let this bother you. Follow the instructions on the screen, all the way to booting from the inserted DOS diskette.

Addressing the controller BIOS

Now enter the DOS DEBUG command. The PC will respond by displaying a blinking hyphen under the last command line. Use the DEBUG command with an address to be entered later to try to call the Controller BIOS. To do this, enter the following after the blinking hyphen:

```
g=c800:5
```

Then press Enter.

If this doesn't result in immediate activity on the monitor, do a warm boot by pressing Ctrl+Alt+Del. Then repeat step 3 and enter the following instruction after the hyphen:

```
g=cc00:5
```

Press Enter again. If nothing happens a second time, you can assume that the hard drive controller doesn't have its own BIOS. Reboot the PC and continue with step 4.

If the controller BIOS responds after DEBUG...

If you were able to call the controller BIOS, you'll see something happening on the screen. Usually the BIOS routines will branch to a selection menu on the screen, from which you can select other options. The important menu items are the ones for starting

subroutines for determining hard drive parameters or the low-level format. We'll tell you how to use them shortly.

STEP 4:

Set up the hard drive

Setting up the hard drive varies, depending on whether you were able to call the controller BIOS.

If the controller doesn't have its own BIOS...

17 or 26 sectors

In this case, set up the hard drive in CMOS SETUP as we described earlier in this section for MFM hard drives. You don't have to worry about the CMOS specifications for sectors and size of the hard drive type you entered. The RLL controller automatically formats 26 sectors, which provides 50% more hard drive capacity than the capacity specified for 17 sectors. However, you don't need to worry about this. Follow the instructions for step 3 from the section on MFM drives earlier in this section.

If you are able to call the controller BIOS from DEBUG...

If you were able to call the controller BIOS in step 3, select the option for setting hard drive parameters from the menu. This option is often called "Change Parameters." Give the number of cylinders and heads. Frequently this option displays selection tables for different hard drive types which you can browse through. Select a hard drive that matches the number of heads and cylinders of the one you're installing. You must save your selection, which usually causes the PC to reboot.

One type for all

Most controller BIOSes will also write an entry into the CMOS. Frequently the controller BIOS will set type "1." While this corresponds only to a 10 Meg hard drive, the purpose of the entry is to tell the system that a hard drive is connected. Other controllers would like to enter "NOT INSTALLED" for the hard drive. Sometimes RLL controllers come with documentation that includes information about this entry.

Once you save the entry about the type and reboot the computer, you're finished setting up the hard drive in the controller BIOS.

STEP 5:

Low-level format

The procedure for low-level formatting the hard drive also varies, depending on which result you get from step 3:

The controller doesn't have its own BIOS...

In this case, format the hard drive the same way you would format an MFM hard drive. Refer to the information on MFM hard drives earlier in this section.

You can call the controller BIOS through DEBUG...

After communicating the hard drive parameters to the controller, call DEBUG again with the address in step 3 to make the controller BIOS active. Now select an option called "Low-Level-Format", "Preformat Harddisk", or "Initialize Harddisk."

A brief dialog with the BIOS routine follows. At the end of the dialog, low-level formatting occurs. The formatting routine works through the specified cylinders and heads. If low-level formatting is successful, you'll see one of the following messages:

```
Format complete
```

or

```
Format successful
```

This concludes the initialization of the hard drive.

STEPS 6 TO 9:

Partition, format, test and mount the hard drive

These steps are the same ones used for an MFM hard drive. Follow the instructions relating to the MFM hard drives earlier in this section.

If any errors occur, retrace the steps; maybe you overlooked something.

Installing a second RLL hard drive is just like installing a second MFM hard drive. Refer to the information on the MFM hard drives earlier in this section for more information.

ESDI hard drive installation

Installing an ESDI hard drive is almost identical to the procedure used to install an RLL hard drive. As you may remember from Section I, the recording principle used by ESDI hard drives is an expanded version of the RLL procedure.

In principle, you can also use the installation steps for ESDI hard drives. We'll explain the differences in the following paragraphs.

ESDI controller with and without BIOS

Different addresses are possible

Like RLL controllers, ESDI controllers also come with or without their own BIOS. We've presented a thorough description of how to determine whether your controller has its own BIOS. Only the address of the ESDI controller is different. Frequently the BIOS address is preset to DC00 by jumpers on the controller board, but C800 or CC00 are also possible. Generally, the ESDI controller comes with documentation that provides this information.

After calling DEBUG, enter the following:

```
G=DC00:5
```

Follow the same procedure described earlier in this section under step 3. If nothing happens on the screen, try the other addresses.

Type 1

If the controller has its own BIOS, set the hard drive to "Not installed" or "None" in the CMOS. If you're able to low-level format the drive using DEBUG without any problems, then the setup in CMOS SETUP is acceptable. However, you may encounter problems. Try setting the CMOS entry to Type 1. The controller doesn't care that this entry indicates a 10 Meg hard drive.

If the controller doesn't have a BIOS, the CMOS entry must provide some information about the physical structure of the hard drive. At least the parameters for cylinders and heads should be entered correctly. You might be able to skip over the sectors since some controllers handle this themselves.

Jumpers on the controller board

Setting the sectors

Often there are jumpers on ESDI controller boards that help determine the number of sectors to be formatted. Usually you have the choice of 35 or 54 sectors. Remember that the values set here correspond to the specifications of the hard drive being used.

Not all ESDI hard drives can be written at a density of 54 sectors; 35 or 36 sectors are normal. See the section on installing RLL hard drives for additional steps to installing a hard drive.

SCSI hard drive installation

Some of the hard drive information we discussed earlier in this chapter applies to SCSI drives. However, there are several important differences to installing a SCSI hard drive.

The SCSI hard drive cable

Only one cable

For one, there's the flat ribbon cable between the hard drive and the controller. Since the SCSI interface is fundamentally different from the ST-506 interface (which supports the MFM, RLL, and ESDI hard drives we've been discussing), the SCSI also requires a different cable to the controller.

A typical SCSI cable consists of 50 lines and integrates control lines and data lines in a single cable. The cable is straight (i.e., it doesn't have any twisted ends typical of the other hard drive cables).

Steps for installing a SCSI hard drive:

1. Set the "Drive Select" jumper on the hard drive
2. Connect the hard drive to the controller and power supply
3. Set up the hard drive
4. Partition the hard drive
5. Format the hard drive
6. Test the hard drive
7. Physically install the hard drive in the PC case

Low-level format isn't required

If you already have experience installing another hard drive type (MFM or RLL), remember that this overview of the steps for installing a SCSI hard drive doesn't include low-level formatting.

Preserve the hard drive ID

One belief is that SCSI hard drives shouldn't, under any circumstances, be low-level formatted by normal means. According to this belief, performing a low-level format would destroy the drive ID entries that are so vital to the SCSI controller. If this occurs, the hard drive would be useless.

NOTE

SCSI hard drives come from the manufacturer already prepared. The SCSI controller recognizes the physical parameters of the hard drive by means of identification marks already placed on the hard drive. Check with your manufacturer for details, and whether you need to low-level format your SCSI drive.

STEP 1:

Set the "Drive Select" jumper on the hard drive

Identify yourself!

You distinguish the various devices that a SCSI controller can manage by a SCSI-ID that you set on the device. This SCSI-ID is basically an address where the device (in our case, the hard drive) can be found, and controlled.

These addresses range from 0 to 7 because the SCSI controller can manage up to eight different devices. Set the address on the hard drive either through jumpers or a set of DIP switches. If you're installing the hard drive as the first, and only SCSI device in the computer, set the SCSI-ID to "0".

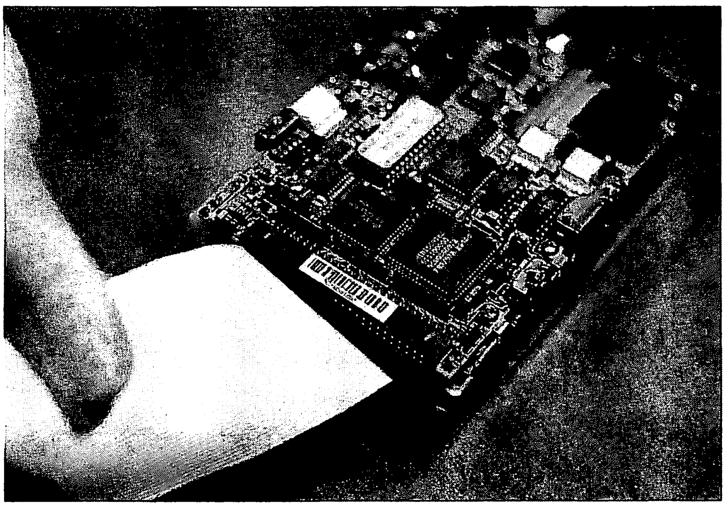
STEP 2:

Connect the hard drive to the controller and power supply

Where is Pin 1?

Like other hard drive systems, this one is also connected to the controller by a flat ribbon cable. As we mentioned, the SCSI interface uses only a wide 50-line cable that combines the control and data wires. The cable has 50-pin post connectors on both ends. Connect the cable to the controller so the labeled side of the cable with PIN 1 connects to the 50-pin connector strip on the controller. Connect the cable to the hard drive in the same way.

The same rule applies to connecting with the hard drive. Usually Pin 1 of the hard drive connector is on the inside, next to the power connector. Ordinarily Pins 1 and 2 or 49 and 50 on the hard drive electronic circuitry are also labeled.



Attaching the 50-pin SCSI cable

After making all the cable connections between the hard drive and controller, insert the controller in a free 16-bit slot on the motherboard.

Supply the hard drive with power the same way you would for all other hard drive systems. Plug in the drive to a free power connection from the power supply. The plug and socket are "keyed" (designed to fit snugly), so it's impossible to plug them in the wrong way unless you use force.

STEP 3:

Set up the hard drive

After making all the cable connections, place the hard drive on the PC power supply with the electronic circuitry facing up. Place it on a pad if possible.

Be patient

Now reconnect the keyboard, monitor, and power supply to the PC. Then insert a bootable DOS diskette in drive A: and switch on the PC. After the autostart routine, the SCSI BIOS of the hard drive controller starts up. It can take a while for the SCSI controller to find the hard drive and display it on the monitor. In a sense, the hard drive sets itself up on the controller.

Don't set up the drive!

Do not set up SCSI hard drives in CMOS SETUP. The correct entry for a SCSI hard drive is "NOT INSTALLED" or "NONE". If a hard drive type happens to be set, the PC displays an error message.

If this happens, be sure to correct the setup entries. We explained how to start SETUP earlier in this section.

If a hard drive isn't entered in CMOS, the PC will load the operating system from the diskette after a message from the hard drive controller.

STEPS 4 TO 7:

Partition, Format, Test, Tighten the screws

Follow the instructions for installing an MFM hard drive for steps 4 through 7. The steps are identical to the steps for MFM hard drives.

If you perform all of the steps and no errors occur, you are finished installing the SCSI hard drive.

Installing two SCSI hard drives...

In this case, remember that the flat ribbon cable that connects the controller with the drive has two connectors for hard drives, and that the SCSI-ID on the second hard drive should be set to "1". The sequence in which you connect the hard drives to the cable doesn't matter to the controller.

You must also run the DOS FDISK and FORMAT programs for the second hard drive. After starting FDISK, be sure to change to the second drive before choosing any other option. Use drive D: for the second drive when you format it; omit the "/s" switch, since you only have to have the system files on the first hard drive (e.g., FORMAT D:).

AT Bus hard drive installation

The more modern PCs use hard drives almost exclusively. AT bus hard drives are the easiest hard drives to install. This is true as long as the PC motherboard has a BIOS that's familiar with the parameters of the AT bus hard drive you're installing or has a "user defined" hard drive type. We'll discuss this in more detail later in this section.

AT bus hard drives do not require low-level formatting

All you need is DOS

The installation procedure is basically the same procedure described in the section on installing an MFM hard drive. However, there is no low-level formatting. Because of this, you also don't need any special initialization programs; all the necessary utilities are part of the operating system.

Installation of an AT bus hard drive in overview

What you can expect

The following list of installation steps should provide an overview. We assume that you only want to install one hard drive. We'll cover installing a second AT bus hard drive in a separate section.

1. Set the Master/Slave jumper on the hard drive
2. Connect the hard drive to the controller and power supply
3. Set up the hard drive in CMOS SETUP
4. Partition the hard drive
5. Format the hard drive
6. Test the hard drive
7. Physically install the hard drive in the PC case

Again, we assume that you've already opened the PC case and that you have unplugged the power cable from the computer.

STEP 1:

Set the Master/Slave jumper on the hard drive

One of the two has to be boss

Except for SCSI hard drives, all the other hard drive types we've discussed require setting the "Drive Select" jumper on the hard drive. AT bus hard drives work according to a different principle. We've already discussed the Master/Slave principle in Section I.

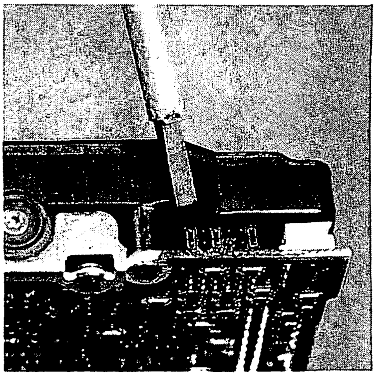
The default settings are sufficient for one hard drive

Generally, AT bus hard drives are preset as "masters without slaves" at the factory. This means that the drive is informed, by the jumper configuration, that it is the "master drive" and the only drive.

Unfortunately, the jumpers are not uniformly labeled. Each manufacturer uses its own labels, so it's impossible for us to provide a general description of the jumper positions. Generally, you can accept the default settings for the first and only hard drive.

WARNING

AT bus hard drives made by Seagate also have a jumper that regulates the function of the control LED on the hard drive. This jumper keeps the LED switched off. You have to set the jumper if you want the LED on the drive or case to go on when the drive is busy. Usually the jumper is labeled "ACT".

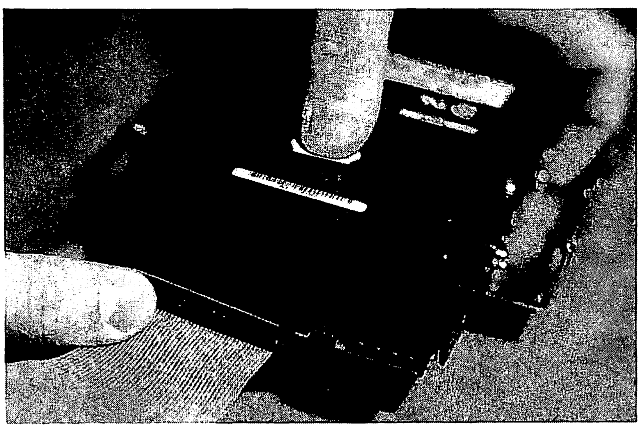


Seagate drives have the jumpers on the side

STEP 2:

Connect the hard drive to the controller and power supply

There are three peculiarities about AT bus hard drive cables that clearly differentiate them from regular hard drive cables. First, AT bus cables are wider and have 40 lines, while other hard drives use 34-line cables. Secondly, AT bus hard drive cables combine control and data lines in a single cable. Thirdly, AT bus hard drive cables are straight. You won't find any twisted cables on an AT bus hard drive cable.



Connecting the cable

Easy cable connections

The cable connects to both controller and hard drive with the labeled side of the cable adjacent to Pin 1 of the contact strips. It isn't possible to plug in the cable incorrectly.

Remember to find a free power cable to connect the hard drive to the power supply. The wrap connections are like the ones on other hard drives.

After cabling the hard drive, place it on its back, resting on a non-conducting surface atop the PC power supply. Try it out before physically installing it.

STEP 3:

Set up the hard drive in CMOS SETUP

After making all the cable connections, you can reconnect the PC to the power supply and switch it on.

Entry required

After the RAM test, your PC will display an error message related to the hard drive. Although the PC is able to find the drive, it discovers that the drive hasn't yet been set up. For example, you might see one of the following messages:

```
C:Drive Error
```

```
HDD Controller Failure
```

In addition, the PC prompts you to start the SETUP program. Follow the instructions on the screen and enter the connected hard drive in CMOS SETUP.

Logical values

You don't use physical parameters to enter the drive in CMOS SETUP, as you would if you were setting up an MFM or RLL hard drive. Instead you use logical values (i.e., values that are valid for "Translation mode"). Ask about this information when you buy the hard drive. The Appendix also lists hard drive parameters.

You'll also find AT bus hard drives with the valid values for translation mode. However, you will find entries that are suitable only for smaller AT bus hard drives (40 Meg) in the hard drive types known to BIOS.

Big hard drives are "User defined"

The only way to set up bigger AT bus hard drives is to make your own entry under "User type". Ignore the entries for "Write Compensation" and "Landing Zone" and set them to "0".

After entering the parameters, save the configuration. See the section on installing an MFM hard drive for more information. Usually the monitor displays instructions about saving.

If it's not possible to make the correct CMOS entry...

Try the default types!

Often the logical parameters of the hard drive don't correspond to any standard type and there isn't a user defined hard drive type in BIOS either. This is frequently the case with older 286s that have an AWARD BIOS or a PHOENIX BIOS. If this happens to you, try out all the default types that correspond to the values of the hard drive you're installing in memory capacity:

```
capacity in bytes = cylinders * heads * sectors * 512
```

To try out these values, enter the type, save it, and reboot the computer. If the PC boots up without displaying any error messages, you can run the hard drive with the parameters you entered. If the BIOS gives you a drive error or controller failure, you must change the entry.

You may have to do without some bytes

If this method is also unsuccessful, you can still try to enter parameters for the hard drive that are lower than the correct values. For example, the PC may accept the hard drive if the number of cylinders is smaller, but you use the right number of heads. You'll be able to tell whether you made the right entry when you boot the PC. If the boot process runs smoothly and the operating system can be loaded from the diskette, the proper entry was used. Save this entry and continue with the next step.

However, this last method always results in a hard drive with reduced capacity.

STEPS 4 TO 6:

Partition, format and test the hard drive

Everything else is the same

If the PC boots up and goes to the DOS prompt after you set up the hard drive, start FDISK to make the hard drive a logical DOS drive. We discussed using FDISK and FORMAT in the section on

using an MFM hard drive. Use the same procedure on the AT bus hard drive. Then use the same method to test the hard drive.

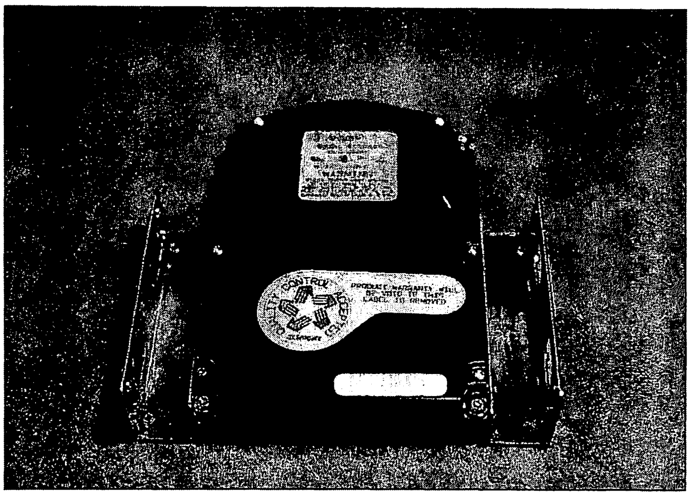
STEP 7:

Physically install the hard drive in the PC case

If the hard drive worked smoothly during the test, you can begin physically installing the hard drive. Unplug the power cable and disconnect all the cables to the hard drive.

Do you need a mounting kit?

There's nothing special about installing an AT bus hard drive. It will easily fit into a 3.5-inch mounting bracket on your PC case. However, you'll need a mounting kit to install it in a 5.25-inch box and mounting rails for older cases. You can also buy mounting brackets that screw into the long sides of the hard drives to make them wider.



AT bus hard drive with mounting bracket

Don't use the wrong screws!

Remember to use the right screws (i.e., ensure that they're not too long). If you use screws that are even slightly longer, you can bore into the hard drive circuitry with the screw. To be on the safe side, check the length needed for the screw before tightening the screws to the hard drive.

If you own a Seagate hard drive, remember that once the hard drive is physically installed, it no longer has access to the jumper for the "Activity LED" light.

After reconnecting all the cables for the hard drive, controller, and power supply, double-check the cabling. If the operating system loads from the hard drive, you're ready to close the case.

Installing a second AT bus hard drive

No cable problems

As we mentioned at the beginning of this section, AT bus hard drives are connected to a straight, 40-line cable. It doesn't matter which drive is connected to the cable first. The first hard drive can be connected to the end of the cable and the second one can be connected to the middle of the cable.

STEP 1:

Master/Slave configuration

Localize the jumpers

The "Master/Slave configuration" is the deciding factor in distinguishing the first and second hard drive. Set and/or clear small jumpers on the hard drive to make this configuration.

The position of these jumpers varies depending on the manufacturer. For example, Seagate places the jumpers for its 40 to 120 Meg hard drives on the side of the drives. Other manufacturers place the jumpers on the control circuitry, or on the front side, next to the power connection. The labeling on the jumpers also varies.

Therefore, we cannot provide a general description of the correct jumper position. Instead, we can only tell you how to locate this position.

There can only be one

Always configure the first drive (i.e., the hard drive entered as C: in CMOS SETUP) as the "Master Drive". This is the drive from which you boot up the PC. The MASTER jumper might be labeled "MS" or "CD". If there is a second drive under the master, a second jumper informs the drive that there is a "Slave" drive. This jumper is often labeled "SP" (Slave Present).

The second drive obeys

Tell the first hard drive (the master) that it has a second (slave) hard drive. Tell the second drive that it is not a master. In other words, clear the "Master" jumper on the second drive. Then both

the first hard drive and the second one will understand that the second hard drive is the slave.

Once you understand this principle, you probably won't have any trouble adapting the drives to each other.

STEP 2:

Set up both hard drives in CMOS SETUP

Enter the second hard drive with its translation mode values in the CMOS table as drive D:. As long as it's possible to make both entries, you won't have any trouble. We'll discuss potential problems later.

After saving these entries, the PC will boot up and try to load the operating system from the disk drive if the first hard drive hasn't already been formatted as the boot drive. If the first hard drive is formatted as the boot drive, the PC will start from drive C:.

STEP 3:

Partition and format the second hard drive

Caution with FDISK

WARNING

We assume that the first hard drive is already formatted and that it contains data. If this is the case, be very careful when using FDISK. If the computer has a second hard drive that is already set up, FDISK will display an extra option, "Select next hard drive" as well as which drive the displayed options refer to. Before partitioning, change to the second hard drive and install a primary DOS partition there.

After successfully partitioning the hard drive and rebooting, you still must format the second hard drive. Type the following to format your second hard drive:

```
FORMAT D: Enter
```

Problems with the second AT bus hard drive

If you have problems installing a second hard drive, first ensure that the second drive works and is free of technical defects.

To do this, connect the (second) hard drive in place of the first (and up to now, only) hard drive and set the jumpers to "Master without Slave". Make the necessary entry in the CMOS and then run both FDISK and FORMAT. If you are able to format the drive without any trouble, you can assume that it is in good working order.

Generally you won't have any difficulties if both hard drives are from the same manufacturer, especially if both hard drives are the same model.

Problems are possible

However, if you're using two different hard drives, you may have problems with the Master/Slave configuration. Usually you won't have any problems combining drives from different manufacturers. Unfortunately, we cannot give you a list of which hard drive types are incompatible and which ones are compatible with each other.

The motherboard is a deciding factor

If two drives aren't working together properly, even though everything is properly cabled and the Master/Slave setting is correct, the cause isn't necessarily the hard drive models. There can be other causes.

Often two hard drives that won't work together on a specific motherboard, work fine when connected to another motherboard. However, the first motherboard may be able to work with two other hard drives.

We are not aware of the technical reasons for two hard drives not being able to work together. Sometimes the only way to solve the problem is to replace one of the hard drives with another compatible model.

Not every hard drive can be master (or slave)

Occasionally a pair of hard drives won't work together unless a particular drive is "Master". As soon as you try to make this drive the "Slave", the combination no longer works. So, if you find a particular combination of hard drives that works, stick with it.

The System BIOS can also cause trouble

The System BIOS can also cause problems. As we mentioned, normally you can set up only larger AT bus hard drives with the user defined setup entry. You use type 47 to set up the drive (USER TYPE). If the second drive also must be entered as type 47, it can place a burden on the BIOS.

Brand new PHOENIX or AWARD BIOS configurations offer two user-defined hard drive types to compensate for this (types 47 and 48). The latest AMI BIOS offers another solution. It's able to distinguish between type 47 for drive C: and type 47 for type D:. Older AMI BIOS configurations cannot make this distinction.

What can the BIOS do?

It's very easy to determine the capabilities of your BIOS. Start the SETUP program and enter different values under type 47 for drives C: and D:. If BIOS is able to distinguish the two different type 47s, then SETUP will display different parameters for C: and D: under type 47 after you save and reboot. Otherwise, you'll see the same entry for both drives, which means that you can set up only one drive as user defined. In this case, you won't be able to avoid entering one of the two drives at a lower capacity, as we described.

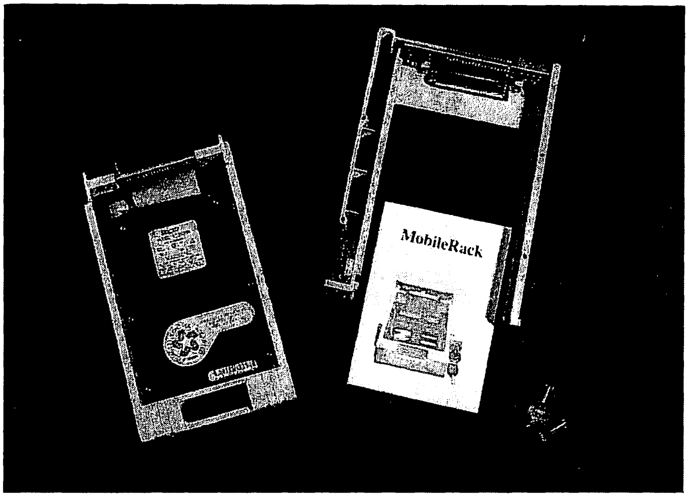
Removable disk system installation

Lately removable disk systems have been making a comeback. First let's talk about the difference between a true removable disk drive and a normal hard drive in a removable frame.

We'll start with a hard drive in a removable frame. In this case, we're dealing with an ordinary hard drive (e.g., AT bus) that's screwed into a frame. The hard drive is plugged into the back of the frame. The plug looks like the Centronics plug of a printer cable. The hard drive gets both current and data from this plug.

Hard drives in removable frames

The companion to this frame is screwed into a 5.25-inch case. The same connectors that are usually located on a hard drive are on the back of this inner frame. On the inside, these connectors lead to a socket that is the counterpart to the "Centronics plug" on the hard drive. You enter this hard drive in CMOS SETUP, as you would a normal hard drive, and the installation procedure is also the same. AT bus hard drives are usually in removable frames because they are so flat.



AT bus hard drive in a removable frame

It makes more sense to use the same hard drives

You can also pull out the removable frame and replace it with another hard drive in a different removable frame. You should always use the same kind of hard drive; otherwise you must continually change the CMOS entry.

It's also possible to install a true removable disk system. While you remove the entire drive from the computer with the hard drives that come in removable frames, removable disk systems change only the data disks. This is similar to using diskettes that have a 40 Meg capacity.

Removable hard drives are SCSI devices

The actual drive is an SCSI device controlled by an SCSI controller. All you need is a simple SCSI controller, since the removable hard drives are quite slow. Since SCSI devices don't have to be set up in CMOS, this system can coexist with, for example, two AT bus hard drives connected to a combination controller. The System BIOS and the SCSI BIOS won't conflict with one another. Installation is identical to that of an SCSI hard drive.

Using utility programs

You should use one of the following programs only when you can't perform a low-level format on a hard drive using DEBUG, an integrated BIOS routine, or one of the low-level format programs, and you know that no defects exist in the hardware.

The two most popular utility programs for installing hard drives are Speedstor from Storage Dimensions and DiskManager from Ontrack. You can use either program to install almost all hard drives.

Both programs contain the data for several hard drives and you can enter the hard drive parameters. We think that Speedstor is the more flexible of the two programs since it is user-friendly and has a larger variety of hard drives. We'll discuss both in this section.

Manual or automatic?

Both programs can automatically perform all the necessary steps to complete a DOS format in a single pass. This includes low-level formatting, setting up partitions, and creating a device driver.

However, you can also perform each of these steps manually. It's usually better to do this because you can use the device drivers that the software generates only when it's impossible to set up the hard drive correctly in the usual way.

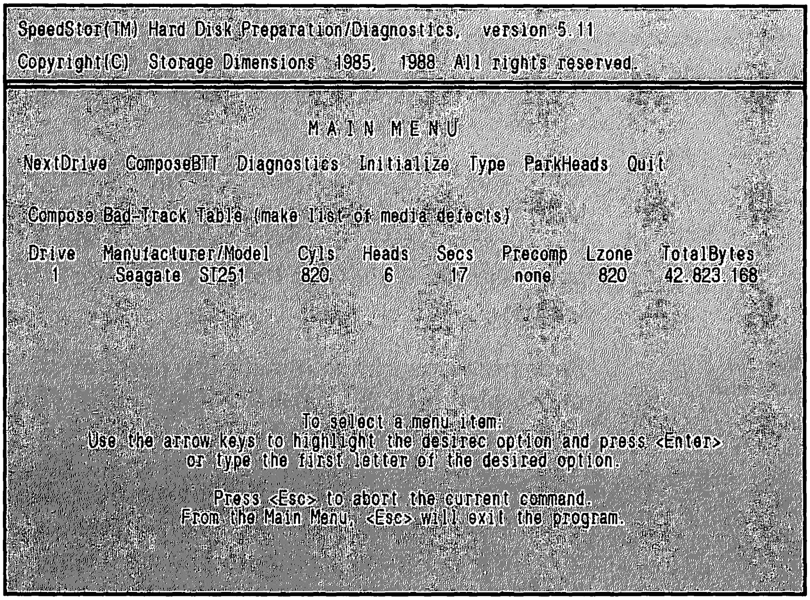
How to initialize a hard drive with SpeedStor

Instead of discussing SpeedStor in detail, we'll briefly explain how to use this program.

We'll assume that you've connected the hard drive and entered it correctly in the CMOS. Boot the PC from a diskette and insert the Speedstor program diskette in the disk drive.

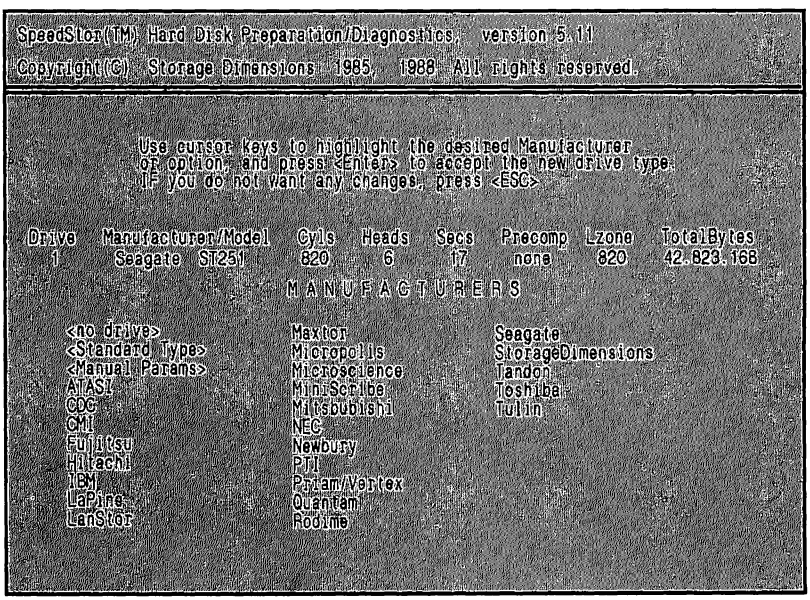
Main menu

After you start SSTOR.EXE (or HARDPREP.EXE if you have an older version of Speedstor), the Speedstor main menu appears. Select the "TYPE" option from the main menu to display a selection list of hard drives sorted by the manufacturer. Try to find your hard drive model and select it. Speedstor then returns to the main menu. The parameters of the hard drive type you selected appear in the data line.



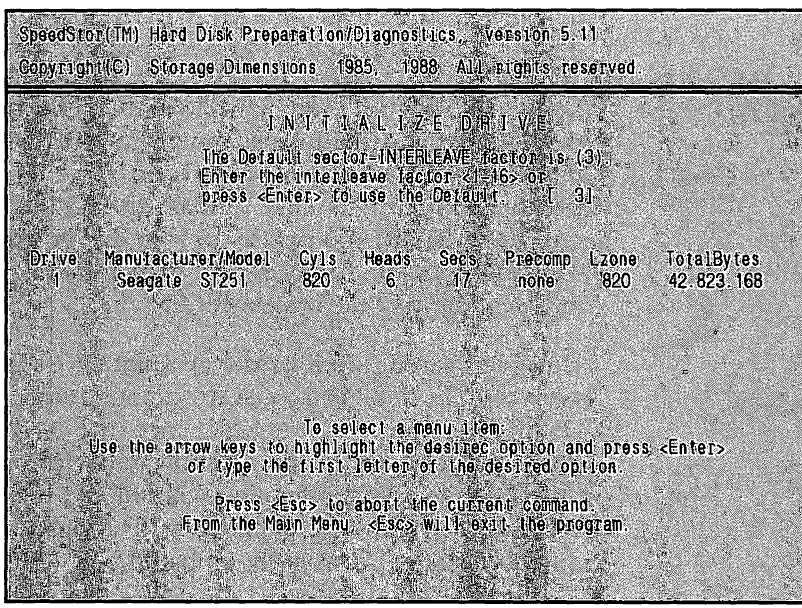
The Speedstor main menu

Speedstor then prompts you for the disk drive number. After you select "DRIVE ONE", a list of several hard drive manufacturers appears on the screen.



Move the pointer to the appropriate manufacturer (our example selected "NEC") and select it by pressing Enter. Speedstor then displays another selection menu listing the various models of hard drives from this manufacturer. This list could be several screen pages in length—use PgUp and PgDn to scroll through the list. Select the proper hard drive model (we selected model D5146).

Now select "Initialize". Speedstor goes to the initialization menu and waits for your input. To low-level format the complete hard drive, highlight the "StandardInit" option. After that, SpeedStor prompts you for more information and gives you the option of entering bad sectors on the hard drive in the BTT (Bad Track Table). If your hard drive came with such a list of bad tracks, enter them here. Another security prompt appears at the end of the dialog and then the program begins running.



Cancel the program in case of error

Under normal circumstances (i.e., if the hardware is all right), the program will process all the cylinders. The program begins at the top, works its way down, and then goes back up. This process shouldn't take more than 5 minutes per 20 Meg of hard drive capacity. If the program takes a long time, this means something is wrong. Press Esc to cancel the program.

After successful initialization, Speedstor displays the message "Initialization successful". Select "Quit" to return to the DOS prompt so you can continue working with FDISK and FORMAT.

Speedstor also accepts manual entries

If the hard drive model you're installing doesn't appear in Speedstor's list, you can also enter your hard drive parameters manually. Speedstor has an option called "ManualParams" for this purpose. However, don't make any entries here unless you are certain that they match those of your hard drive. Low-level formatting a hard drive with the wrong values can damage the hard drive, especially if the values are too high.

When all else fails

Creating a device drive

If none of the previous procedures work, because BIOS doesn't support the drive type, you must have Speedstor generate a device driver that will make the hard drive usable in DOS, provided the device driver is loaded at system startup.

Use the "INSTALL" command to start this program routine from the Speedstor diskette. The program will then determine your partition sizes for the hard drive in a dialog with you. Then it initializes, partitions, and formats the hard drive. The program creates a "HARDRIVE.SYS" device driver and enters it in the CONFIG.SYS file. This device driver manages the hard drive independently of the system BIOS.

However, setting up a hard drive that isn't supported by BIOS is very complicated. You must experiment with different solutions. Doing this requires a lot of experience so you can interpret the error messages correctly or the aberrant behavior of the PC system in this situation. Quite often you will fail and the entire undertaking becomes a frustrating experience. The best way to avoid these difficulties is to be properly prepared.

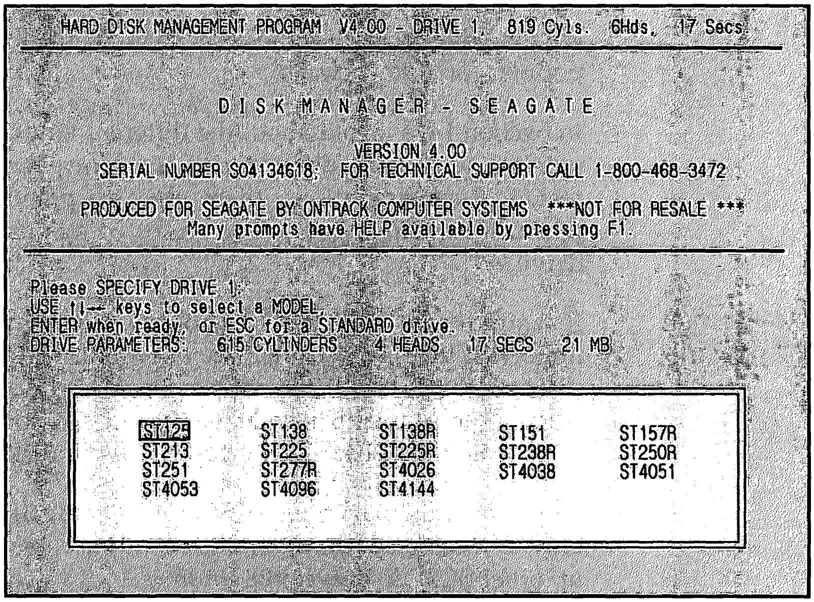
Using DiskManager from OnTrack

DiskManager also provides a number of hard drive models for your selection. However, these are only models manufactured by Seagate. You can also use DiskManager to process hard drives from other manufacturers as long as the parameters match those of the Seagate drive you specify.

To run only the routine for low-level formatting, start the program from the diskette by entering:

dm Enter

The opening provides a list of Seagate hard drive models. Choose the model most like the one you're installing as the default. Later DiskManager gives you an opportunity to change these default settings manually.



DiskManager

Now save these hard drive parameters and change from the "Main Menu" to the "Initialization Menu" to low-level format the hard drive.

Generating a driver for the hard drive

You can also manually enter parameters. Run DiskManager by entering:

dm/m [Enter]

This enters the "Initialization Menu" after you select the hard drive model. From here, you can change the default drive parameters, which allows you to process a hard drive, not made by Seagate, with different data. Activate the "Configuration Menu." Select the Seagate model that most closely matches your own hard drive. DiskManager then gives you the option of changing each hard drive parameter.

7.5 Tape Drives

Because hard drive capacities are constantly increasing, backing up data to diskettes can be a problem. It's almost impossible to back up 100 to 200 Meg of data onto diskettes, mainly because of the time this process would take. So tape drives are becoming more popular for data backups.

In Section I we talked about the different kinds of tape drives. We won't repeat those differences here. However, along with these technical considerations, there are also practical considerations that can influence your decision for or against a particular tape drive.

Additional adapter required

If you decide to install a floppy model tape streamer, it's important to know whether one or two drives are connected to the diskette controller. If two drives are already connected, you will need an additional controller since you can no longer connect the floppy model tape streamer directly to the diskette controller.

However, purchasing an SCSI model tape streamer makes sense only if you already have an SCSI controller, or you intend to hook up other SCSI devices in the future.

What you will need

To install the streamer, you'll need a free 5.25-inch mounting unit, and a free power cable from the PC power supply (or a Y power splitter cable). Before buying a streamer drive, determine what comes with it.

A data cable for connecting to the controller is almost always part of the package. Sometimes, it may be too short, which can be especially troublesome for owners of tower cases. The package doesn't always include backup software, even though it's impossible to perform backups from a tape drive.

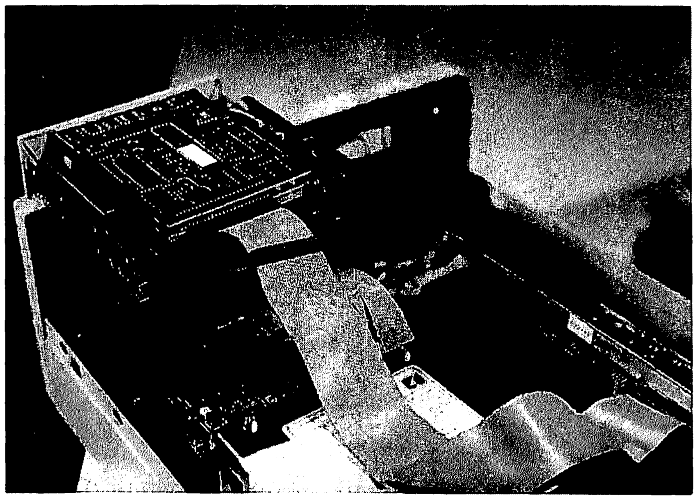
Finally, determine whether you will need mounting rails to install the streamer in a free 5.25-inch mounting bracket.

Floppy model tape streamer installation

The procedure for installing a floppy model tape streamer differs, depending on the number of connected disk drives. Settings aren't made on the tape streamer itself. You can place it directly into the case in which you are installing it.

How many drives are connected?

If only one disk drive is connected, you can use the other free connection for the second disk drive to hook up the tape streamer to the diskette controller. Connect the floppy cable to the tape streamer so the notched side of the contact strap covers the labeled side of the floppy cable. Connect the tape streamer to a free power cable from the power supply as well.



The floppy model tape streamer on the straight cable

DOS doesn't notice a thing

It's not necessary to set up the tape streamer, since the system doesn't assign a logical drive letter to the tape streamer. This fact alone explains why it is impossible to copy to a tape streamer in the normal way (e.g., with the DOS COPY command). To DOS, the tape streamer doesn't even exist. The software supplied with the tape streamer, and only this software, is able to find the drive at a port address specified in the software configuration.

When two disk drives are already connected...

In this case, you can't hook up the tape streamer right away, because the diskette controller is completely occupied by two disk drives. There are two ways to solve this problem.

First, you could replace the controller for a model that can manage more than two disk drives. The advantage of this solution lies in the fact that you aren't filling up any additional expansion slots.

Card without settings

Second, you could use an interface card. Plug it into a free slot and use a straight flat ribbon cable to connect it to the diskette controller. The labeled side of the cable goes on Pin 1 of the connector pin strip. The interface card has a 34-pin connector strip

for the cable to the disk drives and for the flat ribbon cable to the streamer. You cannot change or make any settings on this card.

Frequently these interface cards have a socket for a branch connection from the power supply. It is used to supply power to an external device. If you have already connected the tape streamer to the power supply, don't make another connection here. This could destroy the card or the streamer.

Installing the backup software

Double capacity through data compression

After connecting the tape streamer to the controller and the power supply, you're ready to install the streamer software. Installation will vary depending on the product you are installing. Usually the installation diskette has a file called INSTALL or SETUP that you call to start an automatic installation routine. Some tape streamer models use data compression. This means that the software is able to store either 60 Meg of uncompressed data, or 120 Meg of compressed data on one tape. The software will use data compression only if you specify this during installation.

After you finish installing the software on the hard drive and insert a tape cartridge, you can usually determine whether the tape streamer will be addressed by simply calling the tape backup software formatting a tape. Frequently a message appears before the main menu, such as "Waiting for tape...", while the tape streamer rewinds the tape to its beginning. You can hear the streamer working.

Format the tape

Format a tape to determine whether installation was successful. Usually there is an option for this purpose in the "Utilities" menu item. For example, formatting a tape could take about 60 minutes for a 120 Meg cartridge. If the streamer formats the tape completely, you can almost assume that everything is all right—at least between the backup software and the streamer drive.

Testing

Here's how to check

However, the purpose of the device is to back up data from the hard drive. So first try to back up the DOS directory to the tape. Options for backing up to the tape are called "Backup" options while the ones for restoring are called "Restore" options. Learn a little about the software and do the following test:

1. Create a TEST directory on the hard drive.
2. Copy data from another directory to this directory.
3. Back up the TEST directory to an empty tape.
4. Delete the contents of TEST from the hard drive.
5. Now restore the backup.
6. Check the restored contents of the TEST directory.

If this test was successful, you're finished installing the tape streamer.

SCSI model tape streamer installation

Another, more expensive model of tape streamer works with an SCSI interface. You can run such an SCSI model tape streamer on any controller that conforms to the SCSI standard. This means that you can operate an SCSI streamer along with hard drives, scanners, and other SCSI devices from a single controller. The number of SCSI devices you can connect to an SCSI controller justifies its high price.

Here is an overview of the installation steps:

1. Confirm settings on the tape streamer
2. Connect cables
3. Install backup software
4. Install device driver in the CONFIG.SYS file
5. Format and test a tape
6. Physically install tape streamer in the PC case

STEP 1:

Confirm settings on the tape drive

As you'll remember from our discussion about SCSI hard drives, an SCSI device requires only a valid SCSI-ID to be recognized by the

controller. When setting the ID, it's important to know how many SCSI devices are already connected, or which identification numbers between 0 and 7 are still free.

Suppose that you already have one SCSI device running on your computer, such as a hard drive. During installation, this device is assigned an SCSI ID of "0". Then you would assign an ID of "1" to the streamer when you install it. You can make this setting on the tape drive with jumpers or DIP switches.

STEP 2:

Connect cables

After that, connect the streamer to the same cable that connects the first SCSI device to the controller. Connect it so the labeled side of the 50-line SCSI cable is covered by Pin 1 of the SCSI connector on the tape drive. The drive also gets a power connection directly from the power supply.

STEP 3:

Install backup software

You cannot access the tape streamer without special backup software. Backup software either comes in the package with the tape streamer or you can buy it separately.

Driver necessary?

Now follow the instructions in the user manual for installing the software on your hard drive. Backup programs that include the streamer may also install the device driver necessary for addressing the tape streamer and make changes to the CONFIG.SYS file. In such cases, skip step 4.

STEP 4:

Install device driver in CONFIG.SYS

Driver required!

To be able to address the tape streamer from the SCSI interface, you must enter a device driver in the CONFIG.SYS file that will be loaded into resident memory at every system start. This driver

file comes on diskette either with the tape streamer or the SCSI controller.

You have to copy the driver somewhere on the hard drive also. It's best to copy it to the same directory as the backup software and enter the complete search path. Depending on the product, the driver could have a different name. Make the necessary entry in the CONFIG.SYS file, in the root directory of your hard drive, by adding the following line:

```
DEVICE=C:\[Path specification]\[Device driver name]
```

Only by installing this driver and resetting the system can you access the tape streamer from the backup software.

STEP 5:

Format and test a tape

After formatting a tape, it presents itself during the system start. At the same time, the computer accesses the tape streamer and you will see the control LED light up.

Formatting takes time

Now insert a new tape cartridge and start up the backup software. First try to format the tape. Usually you will find the right option under "Utilities". After you select this option, the tape streamer should start moving the tape. It may need to rewind to find the beginning of the tape.

This could take a few minutes, depending on the size of the tape. If the tape streamer formats the tape without any problems or error messages, everything should be fine. Perform the test described earlier in this section.

Is the configuration right?

However, if you have formatting problems that are not attributable to using the wrong tape, then you didn't install the drive correctly. Usually the problem lies with the configuration of the backup software. Check the configuration again using your manuals. Generally, you'll also find a list of error messages and their meanings in the manual.

STEP 6:

Physically install the tape streamer in the PC case

After testing, you are finally ready to fasten the drive to the PC case. It fits into a 5.25-inch mounting unit, just like disk drives.

Check whether the tape drive works a second time before closing the PC case.

External tape streamers

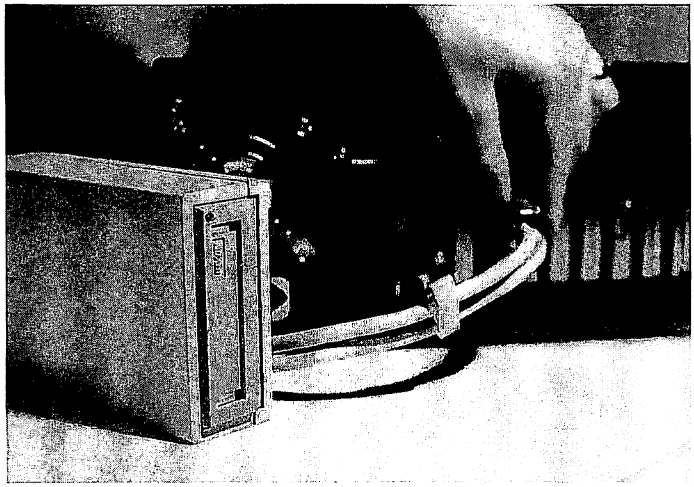
We should mention external tape streamers, although they are becoming less popular.

The basic difference between an external and an internal backup drive is that external devices either have their own power supply, independent of the PC power supply, or they have to be supplied with power from the data cable.

Even external streamers need power

Older external tape streamers usually come with their own power supply. Newer models come with a separate controller card. The controller card has a female, 25-pin socket for the tape streamer connector cable. This outlet sends current to the external device.

The controller card plugs into a free slot on the motherboard, and must also be hooked up to a free power supply line from the power supply. You generally don't have to make any settings on the card; the devices are set by default.



An external tape streamer

Hardware installation before software installation

You may have address problems or other trouble with other cards in the PC. In these instances, you can use jumpers to change the hardware configuration of the card. Please refer to your manual for more information. Remember that making changes to the hardware means changing the software as well.

After cabling the PC and the streamer, install the backup software on the hard drive. Do the same test we described in this section.

7.6 Installing a CD-ROM Drive

It's easy to install a CD-ROM drive. There are internal and external devices. You always connect the CD-ROM drive to its own controller card, or to a sound card that already has the adapter (e.g., Sound Blaster Pro from Creative Labs). Usually this adapter is part of the CD-ROM drive package.

Only one drive for DOS

After connecting the drive to the adapter, you must also link a device driver to the CONFIG.SYS file so you can address the CD-ROM drive like a DOS drive.

Here are the necessary steps:

1. Install controller card
2. Connect cables
3. Add device driver to CONFIG.SYS
4. Configure DOS
5. Test CD-ROM drive
6. Physically install drive in the PC case

STEP 1:

Install controller card

Generally the controller card doesn't require any settings. Frequently it's impossible to make any settings to the controller card. Insert the controller card, as is, into a free slot on the motherboard.

STEP 2:

Connect cables

Simple cable connection

Now connect the controller card to the CD-ROM drive with the flat ribbon cable. Use the connection side labeled "1" on the adapter card and the CD-ROM drive to connect with the labeled side of the flat ribbon cable. You must also connect the CD-ROM drive to the PC power supply using a free power line. Often you have to use a Y power splitter cable because there are no more free cables on the power supply.

STEP 3:

Add device driver to CONFIG.SYS

Device drivers are not uniform

Now copy the supplied software to a directory on the hard drive. Next enter the complete search path of the device driver for the drive in the CONFIG.SYS file. Please refer to the installation manual for information about entering the search path, including information about the entry and any extra parameters.

STEP 4:

Configure DOS

LASTDRIVE

When you enter the device driver in the CONFIG.SYS file, you also determine which logical drive label DOS uses to address the CD-ROM drive. If this logical drive letter is "greater" than "E:", you must also add the line LASTDRIVE=z before the device driver in CONFIG.SYS. Otherwise, DOS will recognize only drive letters A: through E:.

STEP 5:

Test drive

Reading the directory

If all the settings are correct and the driver has been installed correctly, nothing else can go wrong. Reset the PC and check the monitor for error messages. Then insert a CD and try to display the contents of the directory using the DOS DIR command and the drive letter you assigned to the CD-ROM drive. In our example, we entered the following to instruct the PC to read the CD-ROM directory:

```
DIR E:
```

If that doesn't work, check the cable connections and take a look at the device driver in the CONFIG.SYS file.

STEP 6:

Physically install the CD-ROM drive in the PC case

If the drive functions properly, you're almost finished. All you have to do is physically install the drive. When you install the CD-ROM drive, follow the same procedure we described for installing disk drives.

7.7 Motherboard

In this section we'll discuss the motherboard and the components installed on it. Be very careful when working on or with the motherboard, and above all, take your time. Remember, without the motherboard, nothing will run on your PC. Besides, replacing a damaged motherboard is expensive.

> **WARNING**
>
> **Ground yourself!**
>
> All the work described in this chapter involves the danger of damaging components that you touch because of electrostatic discharges. Don't wear tennis shoes or rubber soles, and before reaching into the case or touching a component, touch a metal area on the case to ground yourself.

Make notes of all the changes

You don't always have to remove expansion cards or drives from the motherboard when you're working on it. However, you'll have to loosen cables (e.g., to reach the memory sockets). Write down notes about what a cable connection looks like, and to what it connects, before loosening it.

Take your time and be careful when you work with the motherboard. The material you're working with is fragile and some of it is quite expensive.

Parts are standardized

Usually, you can easily replace motherboards of generic PCs with each other. The mounting holes and spacing of the expansion slots have been standardized.

Remember that, along with the board, you're also replacing the BIOS. However, doing this may lead to problems.

You can easily replace motherboards

As long as you replace the old motherboard with a new one (e.g., replacing a 286 board with a 386 board), and the BIOS of the new board isn't older than the BIOS on the old board, you won't have any trouble, especially if both BIOS configurations were made by the same manufacturer.

BIOS problems

If each BIOS was made by a different manufacturer, determine whether you'll be able to enter the hard drives on the new board as they were entered on the old board. BIOSes from Phoenix or Award don't have a USER TYPE in every version that allows you to enter the hard drive parameters yourself. If you want to continue running two hard drives, determine beforehand whether the "new" BIOS also allows this distinction between two different user defined entries. If it doesn't allow this distinction, you'll encounter problems with your hard drive configuration.

Not all components are compatible

The new motherboard may also be too fast for some cards. This happens frequently when adapter cards have their own BIOS, such as VGA graphics cards. For example, some older VGA cards won't run on all 486 motherboards. Not all manufacturers offer a replacement for the graphics card BIOS. Certain AT bus hard drive controllers can also cause trouble on faster boards. Fortunately, you can easily replace such controllers.

Too fast for old controllers

Frequently problems occur when fast 386 or 486 boards are combined with an old MFM or RLL controller. Remember that problems will probably occur if you use some Western Digital controllers on fast motherboards. Frequently, the hard drives are able to boot up, but may have write errors for no reason at all. This also applies to older MFM or RLL controllers from other companies.

The chip set is important

So if you intend to install a new motherboard, determine which problems you'll encounter. We've found that motherboards with NEAT chip sets are especially dangerous. Models with chip sets from Chips & Technologies are common, especially 386SX systems. If you want to save yourself a lot of trouble, don't use these models, especially if you're buying a used board. Buy your motherboard from a dealer. The dealer can always give you qualified advice about any problems you have with the motherboard.

Installing/Replacing the motherboard

Remember, this chapter is about replacing the motherboard in your PC case with a new one. This is an entirely different task than installing a motherboard in a brand new, empty case. We'll discuss this topic later (Chapter 9).

Preparations

You should keep a notepad handy because you will probably need it. Before we discuss details, we'll provide an overview of the steps involved.

1. Keep a notepad ready
2. Remove the necessary cables
3. Remove expansion cards
4. Remove the old motherboard
5. Add memory chips to the new motherboard and test it (outside of case)
6. Install the new motherboard
7. Test the new motherboard (inside of case)
8. Reconnect cables to case
9. Reinstall expansion cards
10. Reconnect the rest of the cables
11. Make entries in CMOS
12. Test the motherboard again

A big job

As you can see, replacing the motherboard involves a lot of steps. Because of this, errors can occur in several places. The following information should help you perform the job properly.

We'll assume that you are replacing only the motherboard of your PC, and you're going to reinstall the same disk drives, hard drives, graphics cards, and all other expansion boards on the new motherboard.

STEP 1:

Keep a notepad ready

Before you start to take your PC apart, make notes about a couple of things that you will need later.

Write everything down

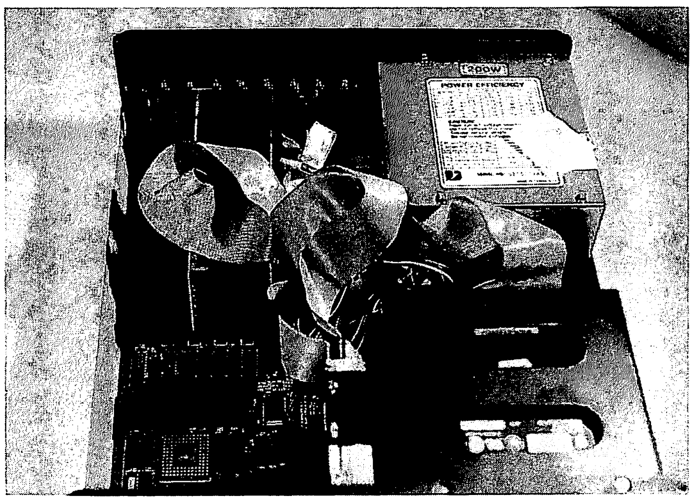
First, write down the hard drive parameters you entered in the CMOS of the "old" motherboard. It's not enough to know the number of the type that's currently set. Types vary depending on the manufacturer of the BIOS. So write down the parameters that

follow the type. This means you'll have to run CMOS SETUP on your computer one more time to copy these parameters. Some BIOS don't display the parameters on the screen immediately; all you'll see is the set type number. In these instances, press Esc or F1 to view a list of the available parameters.

After recording the hard drive parameters, note all the entries for the PC components that you won't be able to activate from memory. After that, exit CMOS SETUP and switch off the computer.

Another piece of advice: Back up your data

Back up your data. Nothing is more frustrating than losing data you've worked hard to compile. Take the time now and back up.



Before the operation

STEP 2:

Remove the necessary cables

Make some room

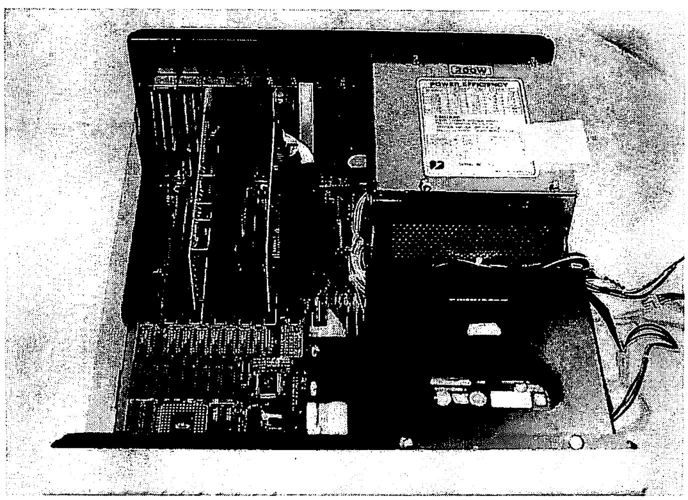
First, unplug the power cable from the computer, then free the PC of all connected devices including the keyboard and the monitor. Draw a diagram with all the cable connections so you can plug everything back in when you're finished installing the motherboard.

You'll also have to remove the thin colored cables from the control LED on the case to the connections on the motherboard. This

includes the loudspeaker as well as the Turbo and Reset switches. Remove these cables and move them out of the way.

Then disconnect the cables on the diskette and hard drive controller. Remember where they were plugged in. You should draw a small diagram on your notepad. Combination controllers often have connections for serial and parallel ports as well.

Remove any cables from these two connections also. Remember exactly where and how the cables were plugged in. Flat ribbon cables have a colored side that will help. Try to move these cables out of the way so they don't disturb you while you're working.



After removing all the cables

Disconnect all the cables that could hinder you while you are working on the expansion cards. Carefully note the position and direction of the connectors if you are not certain how to connect the cables.

STEP 3:

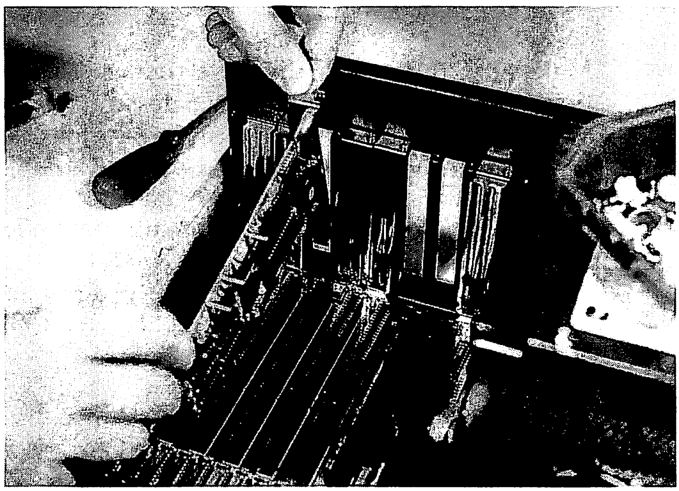
Remove expansion cards

The sequence doesn't matter

Now remove the expansion cards. To do this, loosen the screw from the back of the case and carefully pull the card from the socket. Put the cards in a safe place away from the case. You don't need to

remember the sequence in which the cards were installed; this isn't important on a motherboard with an ISA bus.

If you have several multi I/O cards installed, with serial ports connected through narrow 10-line cables, be sure to write down which interface jumper is connected to which card, and which devices are connected to these ports.



All cards are removed

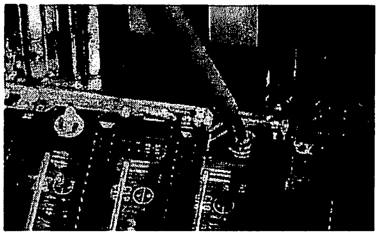
STEP 4:

Remove the old motherboard

Next, remove the old motherboard. To do this, disconnect the power cables that come from the power supply from the board. Take a good look at how they are connected to the motherboard. The three red cables adjacent to each other point to the inside of the board.

Where are the screws?

First, take out the screws holding the board to the bottom of the case. Usually there are two screws, which are normally located at the upper edge of the board, between the keyboard connection and the upper-left corner. However, often the screws are somewhere else. Unscrew the Phillips head screws carefully and remove them from the holes. Make sure the screw driver doesn't slip and touch something other than the screws.



Removing the screws

Spacers can get stuck

Make sure that you really have removed all the screws holding down the board. If your PC is in a desktop case, you should be able to move the board about one centimeter to the left, or away from the power supply.

Hold the board gently with both hands on the left and right edges underneath the board and try to move it to the left. Don't force the board. Often the spacers get stuck. If you can manage to move the motherboard to the left, you should be able to lift it up out of the sliding rails.

Be very careful and gentle when you do this.

Remove the motherboard carefully

Sometimes you have to do some cutting

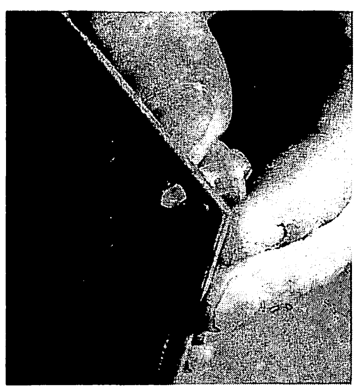
Older cases, especially hinged cases, don't have sliding rails for the spacers. The spacers are fastened to the bottom of the case. It's almost impossible to get the board out of the case cleanly. There are two ways to do this. First, try to pinch the tips of the spacers

together and then pull up the board (difficult, since you can't do it simultaneously with all the spacers) or close the case, turn the computer upside down, and use a sharp knife to cut off the thin plastic disks holding the spacers to the case. Although you'll need to buy new spacers, the board is out of the case. Then simply remove the rest of the spacers from the motherboard slots.

Remove from the bottom

It's much easier to remove the motherboard from mini-towers or upright cases, since you also have access to the back of the motherboard. Many of the mini-towers or uprights allow you to completely remove the bottom of the case, making it considerably easier to remove and install motherboards.

If you managed to remove the motherboard from the case without damaging the spacers, use pliers to remove the spacers from the holes in the motherboard and use them with the new motherboard.



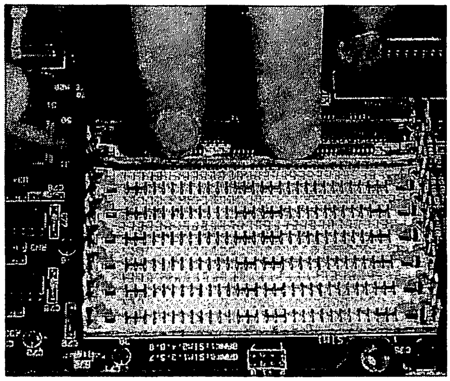
Removing the spacers

If you try to use the installed memory elements on the new motherboard, remove them from the old motherboard now, before we go on to the next step.

Lift SIP modules (the small miniboards) up and out of their sockets carefully.

Clip in memory

Using a small thin screwdriver, carefully pry out SIMM modules from the socket. If the modules are fastened on both sides, loosen the clamps and lift out the modules.



Removing SIMM modules

DRAM chips must be pulled up out of their sockets carefully without bending or breaking off the legs.

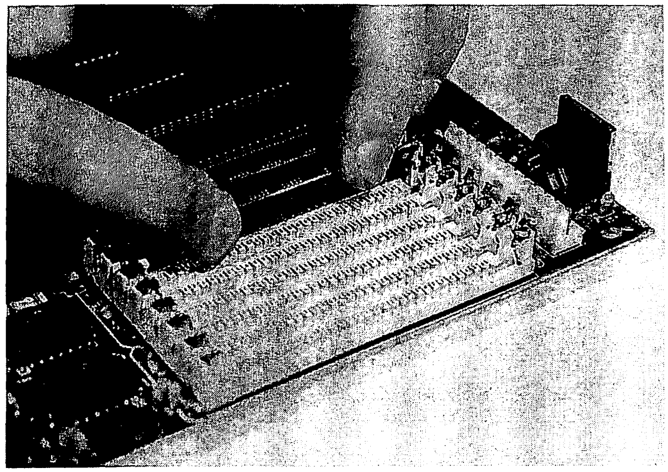
STEP 5:

Add memory chips to new motherboard and test (outside of case)

Before installing your new motherboard in the case, add the necessary memory chips and test it while it's outside of the case.

Now install the appropriate memory modules on the new motherboard and check whether all the jumpers or DIP switches are set correctly for the memory size you have chosen. Use the technical documentation to make this determination.

Make certain you have the correct setting for the display switch, which is a jumper or switch that differentiates between monochrome graphics and color graphics. Always set the switch to color for a VGA card.



Equipping the motherboard with memory

Enabling the accumulator

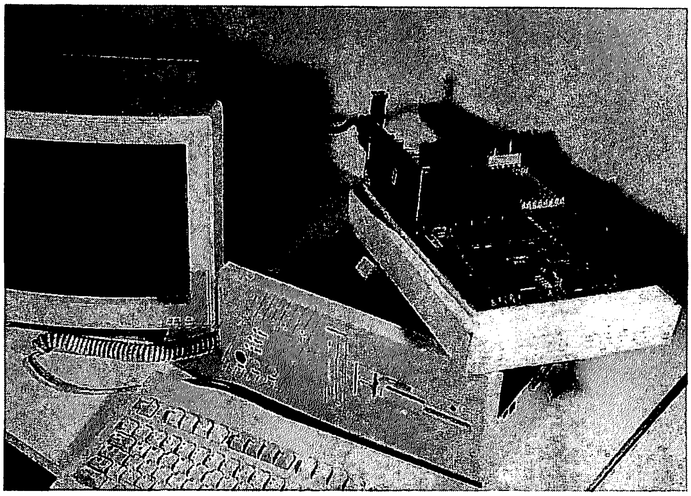
Another important switch toggles between external and internal batteries. If the board has an internal battery, you can tell by the blue accumulator that it's soldered directly onto the board next to the keyboard input (other locations are also possible). In this case, set the jumper to internal battery. Otherwise, the CMOS won't be able to retain the system configuration after you switch off the computer.

Connecting the power supply

After checking all the relevant motherboard, jumper, or switch settings, put a cardboard box or similar sturdy support base on the case and then place the motherboard on top of it so you can test the motherboard.

To test the motherboard, plug in the power supply cable to the motherboard so the three red cables are in the middle of the board while the only orange or white cable is outside on the upper edge. It's impossible to plug the cable in wrong, due to the shape of the plug.

After ensuring that the motherboard works with the power supply, carefully plug in the graphics card, reconnect the keyboard and monitor, and plug the power cable back into the power supply of the computer.



Testing the motherboard

When you switch on the power, the new motherboard should display a picture on the screen, if you inserted the memory modules into the motherboard correctly, all the jumpers are set correctly, and the graphics card also works with the new motherboard.

If the motherboard displays a picture, you can assume that it's compatible to the memory modules and the graphics card. Obviously, you may encounter problems during everyday use. However, currently you can assume that everything is okay. Switch off the power supply and dismantle your test platform.

CAUTION

Ground yourself

Now unplug the power cable from the computer power supply also.

STEP 6:

Install the new motherboard

Danger! Short circuit!

Before physically installing your new motherboard in the case, check whether the small screw sockets and the screws for the motherboard will also fit in the holes on your new board. You

won't need more than two mounting screws. Remove any screws that you don't need from the case, since they could cause ground contact between the case and back of the board.

Find two places where you can connect the new motherboard and remove the rest of the screw sockets.

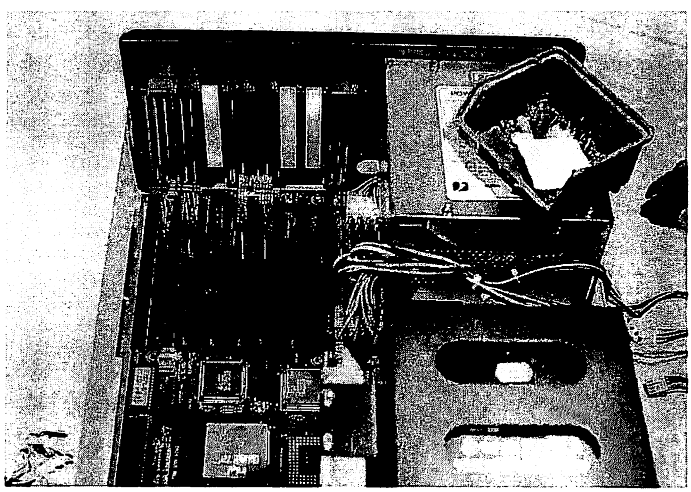
When the spacers get caught

Now carefully place the board on the sliding rails and try to get the spacers in the proper position. Then move the motherboard about one centimeter to the right toward the power supply.

Sometimes the spacers can get caught. Use as little force as possible to free them. If you own a mini-tower or upright this will be easier because you can also reach the board from underneath.

Don't let the motherboard slide away

The motherboard is properly seated when you can move it back and forth without using much force. Find the position in which the screw sockets cover the mounting holes and carefully screw in the mounting screws until you're sure that they will hold the motherboard without sliding. Then connect the motherboard to the power supply as described in step 5.



The new motherboard is installed

This concludes the physical installation of the motherboard.

STEP 7:

Test the new motherboard (inside of case)

The purpose of this test is to determine whether the motherboard is in contact with the case in a place where it shouldn't be. If this happens, the board won't even run.

Reinstall the graphics card and reconnect the keyboard and the monitor. Reconnect the power supply and switch on the PC again.

Is there a picture?

If there is a picture on the monitor, then the test is almost complete. If a picture doesn't appear, and you haven't made any changes to the board since step 5, you can assume that the motherboard is in ground contact somewhere. Carefully disassemble the motherboard and check things over.

The correct memory size should be displayed on the screen.

Is the memory size correct?

The memory size should be displayed accurately to within 384K. So a PC that counts up to 4096K (4 Meg), but stops at 3712K, is completely normal. However, if the same PC counts only to 1024K, most likely the jumper configuration on the motherboard is incorrect. If the amount of variance between the physically installed memory size and the memory size recognized by the computer isn't greater than 384K, everything is fine.

CAUTION

Be careful with motherboards that have a NEAT chip set. The memory configuration for these motherboards can be very complicated. At this point, it's sufficient if the motherboard runs and you're confident that the jumpers on the board are set correctly for the desired memory configuration. With NEAT chip sets, everything else is a question of setting the Extended CMOS. We'll return to this topic later.

Don't be surprised if you see your first error messages after the memory test. You're getting the messages because you haven't yet made any entries in the CMOS, and you haven't connected a drive

from which you can load the operating system. We'll discuss this shortly.

So far so good

We're finished with the most important part; the board is in the case and running properly.

STEP 8:

Reconnect cables to case

Next, reconnect the connection cable between the motherboard and the control LED on the front of the case. Now is the ideal time, since you won't be able to reach it so easily after everything is installed. Usually the connections are in the lower-left corner of the board, at the bottom.

Be patient!

To avoid mixing up the cables, try to follow their path from the light and button so you find the proper plug.

WARNING

This step requires that you reach into the case often and do a lot of testing. Take the time to switch off the PC every time you unplug a cable.

Never work in the case while the PC is still switched on. Ground yourself at regular intervals.

Where is the connection?

Use a two line blue (or blue and white) cable with a two-pin jumper to connect the Reset button to the motherboard. The cable is almost always marked "RESET" or "HWRS" (for hardware reset). If you have trouble finding the cable, either check the documentation of the motherboard, or wait and see what's left over after you finish everything else. The best way to determine whether you used the proper cable is to press the key after switching on the computer (picture must be on the screen). After you press the Reset button the screen clears and the system reboots.

The speaker

This is the easiest connection to find. It's unique because it has four pins. However, only two of the pins are used. For this reason, the speaker cable almost always has a four-pin plug, but only two cables. Usually the connection is labeled "SPK" (for speaker).

Power LED and keyboard lock

Frequently these two functions are on a combined connection. The connection is five-pin. However, only four of the pins are used. Usually the plug is also combined and five-pin. One position is missing. One of the cables is almost always green—this is the cable you connect to the "1" connector pin. After you switch on the computer, this green power LED should light up immediately. If the light doesn't go on, the plug is plugged into the connector strip incorrectly.

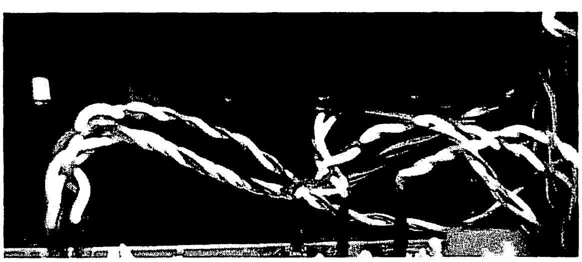
What do I do with the lock?

Occasionally the connection cables aren't five-pin combination plugs. In this case, remember that the cable for the power LED is usually green and white. The two cables lead to the two outer pins, with green going to Pin 1. The two-pin cable from the keyboard lock plugs in between, with both pins plugged next to each other. One pin is free. Use the keyboard lock to determine which pin is free.

Turbo switch
First remove the jumper

This cable is easy to find. It's usually three-pin (black-white-orange) but fits into a two-pin connector. The Turbo switch on the board is marked "Turbo SW" or "TB". Depending on whether this switch must be open or closed to set the board to high frequency, it may have come from the factory with a jumper on the connector pins. This sets the PC to a particular frequency.

To switch the system clock, you must remove the jumper and plug in the three-pin cable from the turbo switch. One line is left over. The only way you can tell whether the switch is working at this point is to watch the monitor during the memory test. In one setting of the switch, the test should run more slowly; otherwise the plug isn't seated properly.



The case connections

Turbo LED

This connection can get complicated if the PC case has a digital display. In this case, the Turbo LED is linked to this display because the displayed megahertz number corresponding with the Turbo switch should be a variable.

Setting the speed display can be dangerous, since it should be set while the computer is running. So there is a great danger of a short circuit when you fumble around with jumpers in a confined area behind the case cover, right above the power switch (its contacts aren't always fully insulated). This could damage individual PC components. A short circuit could even cause critical injuries.

Experiment

If there is no display, connect the yellow and black cable from the Turbo LED to the Turbo LED connection. Usually the connection is labeled "LED" or "TBLED". Since this is a diode, it plugs in only one way. You must experiment to determine the correct one.

You must also do the same until the Turbo LED lights up when the PC is running in Turbo, which is its normal frequency.

Hard drive LED

The hard drive LED is usually connected to the hard drive controller instead of the motherboard. Usually the connector cable is red and white or red and black. This cable also plugs in only one way. Almost always, the red cable goes to Pin 1 of the connection on the controller.

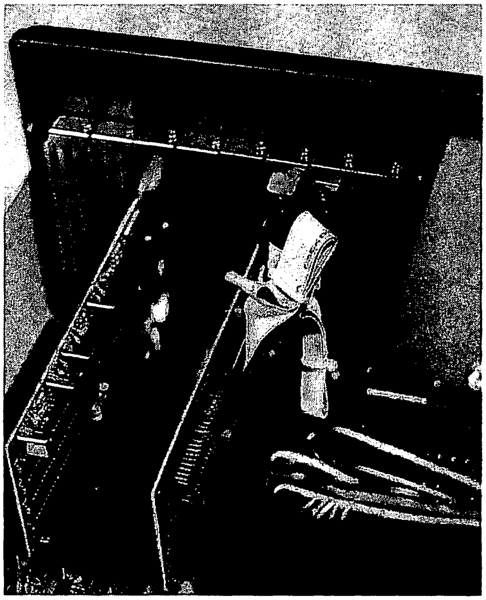
That should be all the case cables. Let's proceed to the next step.

STEP 9:

Reinstall expansion cards

Watch the accumulator!

After reconnecting all of the cables, you're ready to install the expansion cards. Place the expansion cards in the slots using your best judgment. Remember that with many boards, you can't use all cards in the slot closest to the keyboard connection (usually an 8-bit socket) since the accumulator that powers the CMOS is also there. Normally you can't even insert interface cards there. Avoid touching the accumulator with any expansion cards or connectors.



Now the cards are installed

TIP

If possible, leave a slot free between the cards to maximize heat dispersion. Some motherboards have the memory sockets arranged so poorly that long plug-in cards will touch them. Avoid this at all costs, since it can lead to heat damage.

Physically install the expansion cards on the back of the case.

STEP 10:

Reconnect the rest of the cables

Checking your notes

You still haven't connected the drives to the diskette and hard drive controller. However, this should be simple if you took detailed notes.

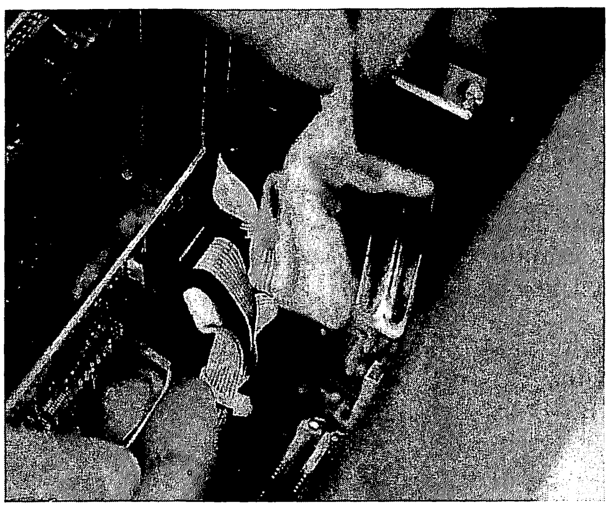
Let's start with the cable for the disk drives. Either the controller has only one obvious connection for this 34-line cable or it goes in

the connection closest to the mounting screw. Connect the labeled side of the cable with Pin 1 of the connector.

If more than one cable from the hard drive leads to the controller, start again by connecting the one closest to the mounting screw. Once again, the labeled side of the cable connects with Pin 1 of the connector.

If there is only one cable leading from the hard drive to the controller, you'll recognize the connector on the controller by its width alone (40-pin or 50-pin). Again, connect Pin 1 with the labeled side of the cable.

Finally, connect the hard drive control LED on the case with the appropriate connector on the controller. We covered this in step 8.



The hard drive control LED connected to the controller

STEP 11:

Make entries in CMOS

In order for everything to run smoothly, you must make the necessary entries in CMOS. Reconnect the monitor and keyboard and plug the PC back into the power supply. After ensuring that all the cards are seated properly in their slots and the cable connections are correct, switch the PC back on.

If something goes wrong

If something goes wrong after you switch on the PC (e.g., a picture doesn't appear or the speaker emits a steady "beep"), switch off the computer immediately and try to find the error. Remember that in step 7 everything was still working.

Remove the cards again and test after each card until you find the error. For more information on finding errors, see Chapter 11.

If the PC displays a screen, shows the startup message, and executes the POST (power-on self-test), it will probably display a series of error messages with a prompt to start CMOS SETUP. Modern BIOS configurations indicate which key to press to start up CMOS SETUP.

Giving the computer the right information

Now start CMOS SETUP. This program is probably a little different than the one from your old computer. First, familiarize yourself with the operation of the program and then enter the correct values for the disk drives, hard drives, graphic cards, etc., in the standard CMOS. Unfortunately, we cannot provide instructions for making the settings because these vary depending on your PC's BIOS configuration.

In Chapter 9 we discuss CMOS settings using an AMI BIOS as an example. If you have questions or problems with CMOS settings, please refer to Chapter 9.

Save again

Modern PC BIOS hardware automatically recognizes the memory size of computers. Normally you cannot make an entry here. If the BIOS displays an error message regarding the memory size ("RAM size error"), but the correct information was already entered after you called CMOS, simply save again. BIOS won't accept the entries until you save this second time.

After you make all of the relevant entries and save, your PC should start up from the hard drive and go all the way to the DOS prompt without any error messages.

STEP 12:

Test the motherboard

In the tests, we assume that your PC was in proper working order before you installed the new motherboard and that you were able to load the operating system from the hard drive. Press the Reset button and watch what happens.

Everything is working properly if your PC does the following:

Boot process

1. Screen turns black after reset
2. VGA/EGA-BIOS message appears (if VGA/EGA card exists)
3. System BIOS message appears
4. Memory test
5. Briefly accesses disk drive A:
6. Briefly accesses disk drive B:
7. Briefly accesses hard drive C:
8. Boot signal from loudspeaker
9. Accesses drive A: (tries to boot)
10. Accesses hard drive C: (tries to boot)
11. Operating system loads from the hard drive

If your PC performs these steps, there shouldn't be any problems. Before closing the case, check the disk drives to see whether they still work. To do this, format a diskette in each drive. Also test the hard drive. Try starting and quitting your programs. Call a directory. Try writing to the hard drive. Call CHKDSK a few times. In other words, give the PC several different tasks.

If errors occur, or if you see error messages on the screen, turn to Chapter 11 and try to find the problem.

The installation process is complete

Remember, don't tighten the screws on the case until you're convinced that everything is in working order.

Expanding main memory

Expanding the memory available for programs and data is becoming one of the most important and popular ways to upgrade a computer. This has occurred because of falling prices and the increasing demands of new software.

Recent developments in semiconductor technology are producing more powerful memory modules that are smaller. So it's possible to install up to 32 Meg of RAM on a normal motherboard. Actually, there are even motherboards with 64 Meg.

Class differences

In Section I we discussed memory management of the various processor classes and the related address boundaries in detail. We don't want to repeat this information here. However, this information is important in order to understand the steps relating to memory expansion.

At the beginning of this section we tried to provide some general rules about physical memory installation. The following statements apply to all processor classes. The only differences are in the memory module used and memory expansion through a RAM card.

Expanding RAM "on board"

You can expand 286 systems to a maximum of 4 Meg of memory "on board" (5 Meg in exceptional cases) by adding memory modules. In very rare cases, primarily with motherboards that have NEAT chip sets, you can install as much as 8 Meg on the motherboard.

386SX boards are usually expandable to a maximum of 8 Meg. Users generally use SIMM or SIP modules.

Motherboards with 386DX or 486 processors can almost always have at least 32 Meg and sometimes as much as 64 Meg "on board". Users upgrade almost exclusively with SIMM memory modules.

The following rules apply to physical memory division on motherboards of IBM compatible computers beginning with 286 processors:

On the bank

1. Memory on board is distributed over two banks (Bank 0 and 1).
2. Each bank contains half of the maximum possible memory. Other divisions are possible if there is mixed distribution on SIP/SIMM sockets and dynamic RAM chips.
3. A bank must always be fully equipped.
4. You cannot mix memory modules of differing capacity within a bank.
5. It's not always possible to combine two memory banks with different capacities.

Exceptions:

As far as memory organization is concerned, boards with NEAT chip sets are exceptions: Almost every NEAT board is different.

Empty banks stay empty

Newer 286 and 386SX boards seem to have 4-bank technology. The banks are marked from bank 0 to bank 3. Actually, however, only two of these banks can be used, depending on whether you want dynamic RAM chips (up to 1 Meg) or SIMM/SIP modules (up to 4 Meg). Combining all the banks is only possible in exceptional cases (5 Meg). You must use jumpers or switches to determine whether you address bank 0/1 or 2/3.

By remembering these rules, you'll be able to decide how to upgrade a 286 motherboard on board, if you can determine which modules you can use on your board.

Example 1:

A motherboard that has 36 combination sockets for dynamic RAM chips can take either 256K chips or megabit chips. All the sockets are filled with 256K RAM modules, totaling 1 Meg.

To add another Meg to memory, giving you a total of 2 Meg, you would have to first remove the installed modules, since each socket is already occupied.

You would have to use megabit modules as replacements (actually 18 modules for 2 Meg). Bank 0 would be full, while bank 1 remained free. By adding another 18 modules in bank 1, you attain the maximum capacity of 4 Meg.

Example 2:

A more recent 286 motherboard is built with the "apparent" 4 bank technology we mentioned earlier. Banks 0 and 1 consist of four sockets each for quadruple 256 chips (256K*4) and two sockets each for simple 256 RAM chips. These sockets are full. The installed memory size is at 1 Meg.

Banks 2 and 3 have two SIP sockets each, and will accept both 256K modules and 1 Meg modules.

You want to upgrade the main memory (RAM) to 2 Meg. If it's possible to run all four banks (manually), there are two options. First, remove all the RAM chips and fill up one of the two SIP banks with megabit modules (2 modules of 1 Meg each = 2 Meg). You can also leave the RAM chips and fill all the SIP sockets with 256 modules (4 modules * 256K = 1 Meg plus 1 Meg in DRAMs = 2 Meg).

Different options

The first option is certainly the better of the two, since it allows for an additional upgrading to 4 Meg by simply adding extra modules. The second option, however, fills up the entire board. You would have to remove some installed modules to upgrade, thus forfeiting the use of those modules.

As you can see, it's very important to plan the most economical way to upgrade memory.

You can use the same principles for larger memory capacities.

Suppose that you have a 386 motherboard with eight SIM sockets equipped with 4 Meg. How many modules do you have in how many sockets?

4 Meg modules

The only possibility is that bank 0 consists of 4 SIM sockets and is filled with 1 Meg modules. There are only two options for an upgrade based on the installed memory.

First, you could expand to 8 Meg by filling bank 1 with 1 Meg modules. Secondly, you could upgrade to 20 Meg by filling bank 1 with a total of four 4 Meg modules. However, this will work only if the board is able to process these modules (check your documentation).

Now let's discuss how to use these options to upgrade memory.

STEP 1:

Remove "old" memory modules (if necessary)

If you're removing memory modules, you must remove some or all of the currently installed modules, then you must begin with step 1.

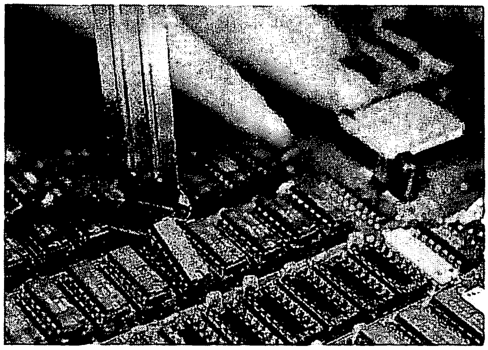
Removing dynamic RAM chips

Don't bend anything!

Make enough room inside so you can easily access the RAM banks. Remove cards that are in your way.

CAUTION

Be careful when removing dynamic RAM chips from their sockets. Don't bend any of the chip pins. You can buy a special pair of chip pliers from your computer dealer, or you could also use the bent side of one of the cover plates from one of the free expansion slots. Holding the front side, lift the chips carefully until you can pull them out easily. Don't lift up on the sockets.



Removing a RAM chip

Removing SIP modules

Delicate pins

Grab SIP modules with both hands on the two upper corners and pull them slowly from their sockets. If the modules are seated too tightly, try carefully prying them up with a plastic tool. Remember that the pins on the SIP modules are very delicate.

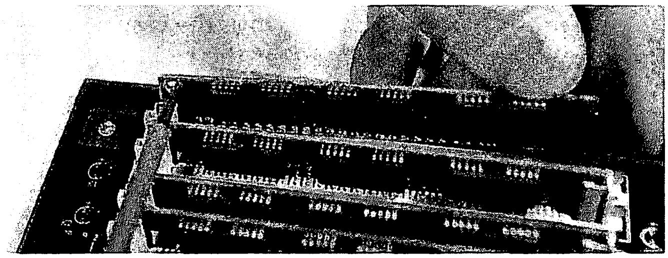
Removing SIMM modules

SIMMs come with snap connectors and wrap connectors. SIMMs with snap connectors are easy to remove. Undo the clips, unsnap the modules, and remove them from the sockets.

CAUTION

Be careful with plastic clips; you may overlook the tiny plastic noses, which are vital for seating the modules. These can break easily.

If the SIMMs are seated in wrap connectors, then you will also find a plastic clip that snaps into the round lock holes on the sides of the modules. Bend the clip back while pulling it up. It's a good idea to take a small plastic pen and pull the modules to the top.



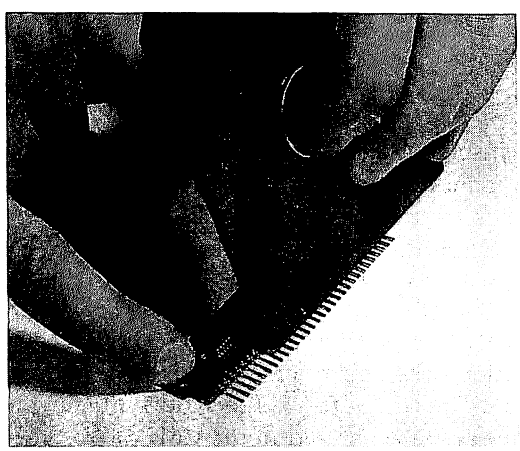
Pulling SIMMs from wrap connectors

STEP 2:

Insert the new memory modules

You won't plug them in the wrong way

Next, insert the new modules. With SIMM or SIP modules, this isn't very difficult. You can't insert SIMM modules the wrong way because they have a notch on one side. Usually, line 1 on both the line and the socket is labeled. SIP modules don't have this notch, but they are also usually labeled. If you bend any pins, simply place the module on a smooth flat surface and straighten out the pins with a sturdy, square object (e.g., a 3.5-inch diskette).



Straightening out bent pins

Inserting dynamic RAM chips requires a certain amount of dexterity. Ensure that you insert the chips correctly. Every RAM socket has a notch or some other mark on its front side. RAM chips are also notched or marked accordingly. Both marks or notches

must go together. First, turn the case so the sockets are crosswise, with the marks on either the right or the left. Insert one side of the chips into the socket so the pins of this side are sticking out in the holes. Gently insert the other side and push in the chips.

Crossed pins

This takes some practice. So, check each chip carefully to ensure that it's seated correctly. If one chip is out of place or bent, problems can occur.

A pin out of place

Unusual numbering

Let's discuss how the memory banks on the boards are marked. Usually a row of memory sockets is marked as either bank 0 or bank 1. However, some boards have the SIMM sockets marked from 0 to 7. In these instances, the first four sockets in the bank are bank 0.

You'll also find the following distribution: SIMMs 0,2,4,6 make up bank 0, while SIMMs 1,3,5 and 7 are bank 1. Generally you can get the necessary information from the documentation to the motherboard. If you're not sure, you must experiment. A picture won't be displayed until bank 0 is filled up.

STEP 3:

Setting up the new memory

After inserting all the modules correctly, read the documentation to your motherboard to determine whether any jumpers or DIP switches should be set. Most likely, you will have to set one of these. Often this is how you indicate the module size with which you're working.

Memory recognized!

If all the switches are correctly set, the computer will immediately recognize your new memory size during the power on self test. The computer will recognize the new memory size, even if another value is entered in the CMOS.

However, this isn't the case with NEAT chip sets. Here you must make the correct entry in the Extended CMOS before the system recognizes the memory. To determine how much memory the system recognizes, reconnect the PC to the power supply, the monitor, and the keyboard. Then switch on the PC.

The memory size should match

After the BIOS message, the system counts the memory. The value can deviate as much as 384K from the intended memory size, since some BIOS systems deduct the disk space required for the shadow option. If the value doesn't match the memory size you installed, double-check whether all modules are correctly seated and whether all the switches on the motherboard are correctly set.

If the system recognizes the correct amount of memory, the system BIOS will immediately output an error message after the power on self test is completed. For example, you might see the following error message:

```
CMOS RAM SIZE ERROR, RUN SETUP
```

Don't be surprised at this message!

If you start CMOS SETUP then, you may be surprised. In many cases (e.g., with AMI BIOS), the new RAM size is already entered correctly, so all you have to do is save it again. In other cases, you must enter the new amount manually. Remember that you would enter 4096K of memory, for example, as 640K "Base Memory" and 3072K "Extended Memory". The 384K between 640K and 1 Meg are used for the Shadow option.

In Chapter 8 we discuss CMOS settings using an AMI BIOS as an example. Refer to this chapter for more information.

Now save these settings. The PC will then reboot and should continue all the way to the DOS prompt without any error messages. You are finished expanding RAM.

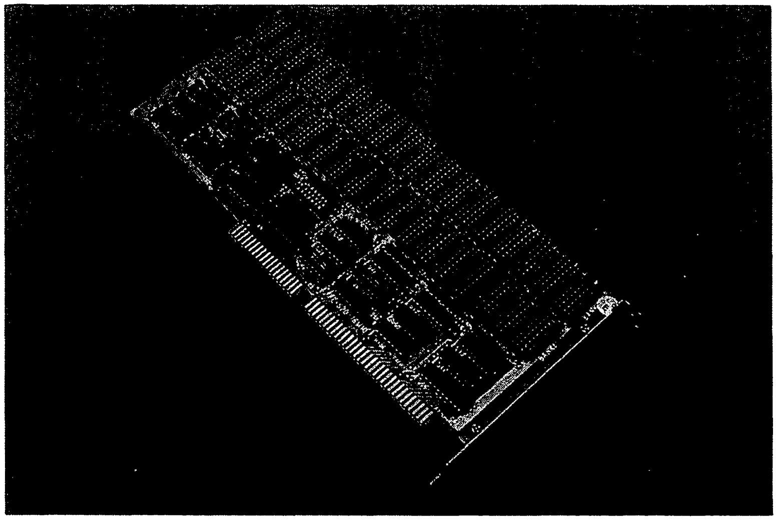
Using memory expansion cards

Memory expansion cards are becoming less popular because the RAM capacities that can be achieved on board have been increased significantly through the new semiconductor technology.

Only when the board is full

However, memory expansion cards are still used and, in many cases, they are quite useful. Generally, you don't use a memory expansion card until you've filled up the motherboard.

RAM cards are also organized into banks. The same rules we mentioned for memory organization on motherboards also apply to RAM cards. Some RAM cards can be equipped with DRAMs, but you can also use SIMMs on memory expansion cards.



A 16-bit RAM card

Setting the start address

A memory expansion card usually has a row of switches for setting the start address of the card, as well as the type and size of the upgrade. The start address refers to the memory size at which memory physically begins on the card, and is no longer on the motherboard. So if the motherboard is at full capacity with 8 Meg, in this case you would set the start address of a memory expansion card at 8192K. To make the proper settings, you must have technical documentation.

You must also set up the card memory (i.e., enter the total RAM size in CMOS SETUP). This is the total amount of memory both on board and on the card.

Installing expanded memory (EMS)

In the first part of Section I we provided a detailed description of installing expanded memory. The most important factor for configuring EMS memory is the processor.

You can easily configure EMS memory for 386 and 486 motherboards. The hardware doesn't have to be changed. All you need is MS-DOS 5.0. To install 1024K of expanded memory, add the following three lines, in the same sequence, to your CONFIG.SYS file.

```
DEVICE = C:\DOS\HIMEM.SYS
DOS=HIGH
DEVICE = C:\DOS\EMM386.EXE 1024
```

If you don't specify a special size, the system uses the default setting of 256K reserved for EMS. To enable the setting, reboot the computer. The size and division of the EMS memory you've installed appears on the screen. For a closer look at the EMS memory, press Pause to halt screen output.

Not all 286s can have EMS memory

The motherboard is the deciding factor on a 286

You must use jumpers or DIP switches to set 286 motherboards to EMS. However, this isn't possible with all 286 motherboards. If this is possible with your motherboard, you still need the right EMS driver for your motherboard. If you don't have the right driver, an EMS driver designed for other motherboards probably won't work on your motherboard.

If your board is able to configure Expanded Memory, you must enable specific switch settings on the board. When you enable these settings, the motherboard switches off a portion of the memory, which no longer appears during the power on self test. This portion of memory is also removed from the CMOS (i.e., the entry refers only to the remainder of the memory).

Then copy the supplied EMS driver, from the diskette that came with the board, to the appropriate directory, specifying the complete directory path, if necessary. Then, enter the following line in the CONFIG.SYS file:

```
DEVICE = EMS.SYS (size in kilobytes)
```

Also, the specified memory size must match the actual memory size.

After rebooting, depending on the memory size you specified, you set up some memory pages of expanded memory. The driver could have a different name. However, usually the letters "EMS" or "EMM" will appear somewhere in the name.

Replacing the system BIOS

Occasionally, you must also replace the BIOS, for example, to enter other hard drive types.

When you replace the BIOS you can never be sure that your motherboard will run with the new BIOS. Often, everything seems to be all right at first.

Only later do you notice mistakes. Replacing the system BIOS with a BIOS from another manufacturer can always cause problems.

Originals have serial numbers

Because of these problems, you must ensure that you use the right BIOS with the right board (e.g., use a 286 BIOS with a 286 board).

The system BIOS usually consists of two EPROMS. The EPROMS have labels that list the manufacturer, a copyright notice, and a serial number. The two sockets are usually marked "High" and "Low." The newer boards often have only one EPROM.

Keyboard BIOS

Basically, you must experiment. Remember that as long as the power is disconnected and you frequently ground yourself, you can't destroy anything. Pull out the two BIOS EPROMS from their sockets and then install the replacement EPROMS.

Ensure that you connect the new EPROMS correctly. Sometimes a keyboard BIOS is included; this is usually longer and plugs into a socket near the keyboard input.

It doesn't always work

If you don't see a picture on your screen within seconds after switching on the computer, switch the two chips around; "High" and "Low" may be mixed up. If that doesn't work either, you won't be able to use the new BIOS.

If your board runs with the new BIOS, first make all the necessary entries in the CMOS and save them. Then try working with the system (format diskettes, write to the hard drive, tap the memory).

Reset the system a couple of times in a row. In short, test your PC to determine whether it runs as it should. If it does, then you've successfully replaced the BIOS.

Expanding cache memory

Today almost all normal motherboards with 386DX and 486DX processors have external memory caches. These external memory caches consist of static RAM chips. The standard size of a cache on a 386 motherboard is 64K. 486s have a cache size of up to 256K.

When the first motherboards equipped with caches were introduced, some of them had only 32K capacities. You can upgrade some of these boards to double the cache capacity.

The architecture of the board is more important than the size of the cache upgrade. The user's manual included with the motherboard contains this information.

In Section I we mentioned that upgrading the memory cache of a DOS computer usually isn't useful. However, we'll provide some practical tips for doing this.

Similar to DRAMs

Since there is no uniform cache organization on the various motherboards, we can't provide instructions that apply to all motherboards. However, this procedure is similar to upgrading RAM.

The cache also has two banks, one of which must always be full. Also, you may have to remove the old modules before you can upgrade. The memory chips look like long dynamic RAM chips.

Since the terms used to describe cache models can be very confusing, you should take your documentation to a dealer and ask him/her to find the proper cache elements.

Determine the cache size

Ensure that you plug in the new cache modules correctly. You may also have to change the settings of a jumper on the motherboard to the new cache size.

Not all system BIOS display the cache size on the monitor during the power-on self-test. It's not necessary to set up the external cache in CMOS SETUP.

However, you often have the option of completely disabling the cache memory in CMOS Setup. You should definitely take a closer look at this setting.

Replacing the processor

Actually, there are only two reasons for replacing the CPU. One reason is that you suspect that the installed CPU is defective, and you want to replace it to see if you're right.

The other reason is that you have a multiprocessor board, on which you can use different 486 CPUs (486SX-20, 486DX-25,

486DX-33). In this case, the clock of the CPU will probably have to be replaced also.

Wasted money

You won't notice a significant improvement in your system's performance if you replace the CPU on a standard system board with a more powerful CPU.

Depending on which CPU type you have, you'll handle them differently. There are all different kinds of 80286 processors. The oldest 80286 processors are the easiest ones to replace.

The chips are long, like the keyboard processor, with pins on the left and right. You can treat them like dynamic RAM chips.

Different types of 286 CPUs

Other 286 models have the same shape as a ceramic plate and are located underneath a metal cooling fin. If you loosen the clips holding the cooling fin, you'll be holding the metal cooling fin and the CPU. Watch out for the holes in the corners when you reinsert it.

Another type of 286 is very difficult to remove. It is seated in a square plastic socket, which covers it entirely. There are narrow slots at each of its four corners. You could pass a thin object through the slots to get underneath the CPU, and lift it up. It's very difficult to do this without using a specially designed tool.

SXs are stubborn

It's very difficult to replace processors of the 386SX generation. The CPUs are usually soldered directly to the motherboard.

Caution with 386 models!

The 386 and its successor the i486 are in a pin grid case seated on a normal socket in open access. Use a thin screwdriver to gently lift it out of the socket by its sides.

CAUTION

Be careful with the pins because they break easily. Avoid all types of shock, and store the processor in a safe place where it won't fall to the ground. When you insert the replacement CPU, be sure to match the beveled corner of the chip surface with the corresponding marking on the processor socket.

The quartz must also be replaced

We mentioned that when you upgrade a multiprocessor board, you must replace the quartz (clock) along with it.

Read the board documentation for more information. You'll also have to change a switch that provides information about the processor type.

Installing/Replacing the coprocessor

Installing a math coprocessor should take about five minutes. First find the socket that holds the coprocessor. On 386 boards, this is a square socket covered with a two or three tiered plate with holes punched in it. Three tiered sockets will hold either a 387 coprocessor or a WEITEK coprocessor.

Insert the 387 coprocessor so the outer tier of holes is free. Ensure that you plug it in correctly. The beveled corner of the coprocessor chip must match the appropriate marking on the socket.

Clock

With 386s, the math coprocessor's cycle is synchronized to the main processor. This is why the coprocessor must be designed for the highest CPU cycle. However, some 386 boards give you the option of using a slower coprocessor. In such cases, the coprocessor gets its own clock.

However, you must set this change to another clock through jumpers on the board. Often, you have to use jumpers or a CMOS entry to set up the coprocessor.

After installation, call the CMOS SETUP program and check whether the coprocessor must be set up. The entry for this is usually located in "Advanced or Extended CMOS".

An introduction to the coprocessor

The 80287 coprocessor is a long, rectangular chip that looks like a keyboard processor. Plug it in its socket and enable it from a jumper on the motherboard. Usually you must also set it up in SETUP.

The only reliable way to test the coprocessor is to use the test programs that came with the coprocessor. Most system information programs, such as the Norton System Info program, display only the existence of the chip. So you still don't know whether the coprocessor is working properly.

7.8 Expansion Card

Many PC users install expansion cards on their PCs. However, even though this procedure usually doesn't require much technical understanding or manual dexterity, many users have problems with expansion cards. Before explaining how to install an expansion card, we'll ask some basic questions.

Is the proper slot still available?

Although this may not seem important, this requirement frequently causes problems. This is especially true if you have a brand name machine with a non-standard motherboard, or if you own a computer with a slimline case. In these instances, you may not have an extra slot.

Just what is the correct slot? As you probably know, most motherboards have two types of slots, which have different lengths. One type is a short 8-bit slot, while the other type is the longer 16-bit slot, which represents the actual AT bus.

8-bit or 16-bit?

Regardless of the type of slot in which they're inserted, 8-bit cards will perform the tasks for which they were designed.

However, this doesn't apply to 16-bit cards. These cards must be plugged into a 16-bit slot; otherwise they are useless. Sometimes inserting a 16-bit card into an 8-bit slot can damage the hardware, especially if the contacts of the card touch components on the motherboard. If this occurs, you could short circuit the board.

Does the plug fit?

Some manufacturers make the hole in the back of the case for the expansion card so close or so square that there isn't enough room to plug in anything near some of the slots (e.g., a printer cable).

The local requirements of an expansion card can also be important. For example, you may not be able to add a long card because other PC components are blocking the card's path. The mounting kit of a floppy disk drive or a hard drive usually causes this problem. However, sometimes the memory banks of the motherboard can be an obstacle for the expansion card, especially if the memory banks are filled with SIMMs or SIPs.

Local inspection

Before buying your expansion card, determine how much space is available in your PC. A quick glance at the back of the case isn't sufficient. Open the case and determine whether you have a free slot. Expansion cards that don't have an outer connector might otherwise look like a simple cover plate. If you open the case and

discover that there's not enough space, don't give up hope. Sometimes you can make room by transferring an existing card to a different slot and then plugging your new expansion card into the slot you just freed up.

Trading places

You may be able to use this procedure when you want to install a 16-bit card, but only find an 8-bit slot that's free. Perhaps your system has an 8-bit card plugged into a 16-bit slot somewhere. If you plug this card into the 8-bit slot, you can free up a 16-bit slot.

Cable connections are also important. A cable that's too short could also ruin your plans. In this case, you may have to make several switches.

Determining the best slot

You can use almost any slot as long as it meets the criteria we mentioned earlier. If you can choose from several slots, you might want to consider a few points.

If you plan on making future upgrades, you should try to keep as much room free as possible. Avoid long cable paths that might have to lead through other expansions. Also, if you install a long card, remember that you may no longer be able to reach some components of the main board, such as the coprocessor socket or the RAM banks.

Disturbances

Occasionally, if the PC power supply is divided, the graphics card can be affected. This results in a noticeable decrease in the quality of the picture (swimming). This problem frequently occurs when the monitor cable is poorly shielded. Because of this, we recommend installing the graphics card as far away as possible from the power supply. Usually, the best slot is the one on the far left.

Configuring the card

Set the cards beforehand!

Most cards, especially add-ons, must be set from jumpers or DIP switches. For example, you must specify which interrupt or DMA channel the card can use. Standard expansion cards are usually preset. However, always check this setting before installing the card. Once the card is screwed into the slot, you won't be able to recognize much. If you use a pair of pliers or a screwdriver to change settings on the jumpers once the card is installed, you could damage the card.

When the card isn't compatible

You should determine whether a card is compatible before purchasing the card. Not all expansions are compatible with the installed components in the system. For example, usually you won't be able to install a modem card in addition to four existing serial ports. Usually it's also impossible to install a second game port. If you have a card (e.g., a Sound Blaster card), which has an additional game port, ensure that you cannot switch it off by changing the setting of a jumper.

This also applies to installing a second printer port or a scanner card. If you aren't sure whether the expansion you're planning could cause problems, read the appropriate chapter in Section I before beginning the installation. The chapters in the first part of the book discuss the special problems linked with IRQs, DMAs, and port addresses.

General installation procedures

The procedure for installing a card is basically the same for all the various cards. We'll give you a general description of this procedure in 10 steps. Then we'll discuss the special features involved in installing the most common expansion cards.

STEP 1:

Prepare the central unit

Place your computer on a sturdy surface and remove all exterior cable connections. Most importantly, remove the power supply cable. Don't force the cables. If you cannot pull out a plug easily, it's probably also attached with screws. Use a small screwdriver to remove the screws from the sides of the plug and then pull out the plug.

STEP 2:

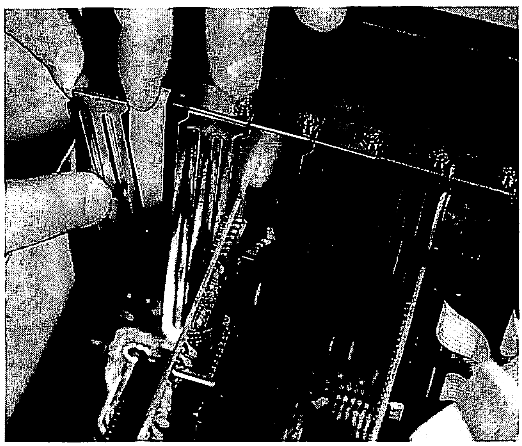
Open the case

Next, open the case as we described in Section 7.1.

STEP 3:

Prepare the slot

Now find an appropriate free slot or rearrange your existing expansion cards to free up a slot. Then remove the cover plate from the slot on the back of the case. Use a Phillips head screwdriver to unscrew the screw on the top of the blank filler and then carefully pull out the blank filler from the slot.



Removing a slot cover plate

WARNING

If the screw falls while you're unscrewing it, stop what you're doing and find the screw. Otherwise, the next time you switch on the system, the screw could cause a short circuit and destroy the entire motherboard.

STEP 4:

Make some room!

Give yourself enough room to work (i.e., remove anything that might get in your way when you install the card). Usually, the cables from the other cards will get in your way.

Make notes about where the cables go and how to plug them in and then pull them out. Doing this is much easier than trying to repair a damaged cable.

STEP 5:

Configure the card

Settings

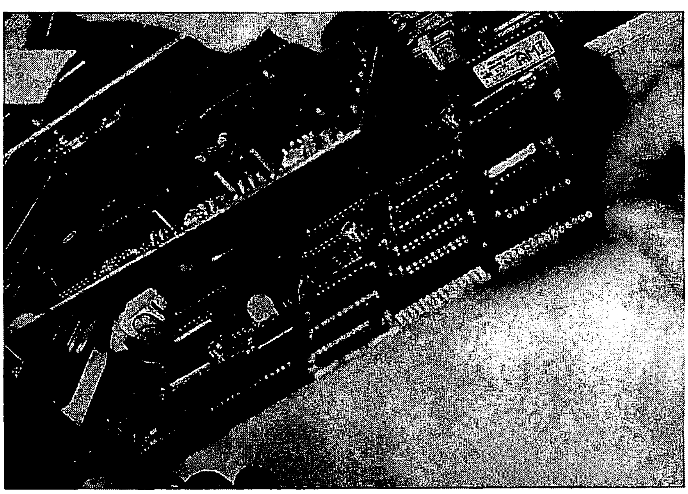
Check the jumper positions or DIP switch settings and correct them if necessary. If your card requires cables inside the computer, determine whether there will still be enough room for the cable when the card is installed. Then attach the cables.

Make sure you plug the cable in correctly; otherwise you'll have to remove the card to turn the plug around.

STEP 6:

Insert the card

Now insert your new card in its slot. To do this, grab the card with both hands and plug it into the slot.



Inserting an expansion card

Don't handle the contact strip on the bottom of the card. Also, avoid putting any pressure on the components. Otherwise you may damage something. Then push the card down into the slot with your thumbs. Don't use force because the card may jam in the slot.

Bending and breaking

Now pull the card out again and notice how it was seated when you installed it. Your expansion card may not fit properly in a slot on an inexpensive case. If this happens, try a different slot. This usually solves the problem.

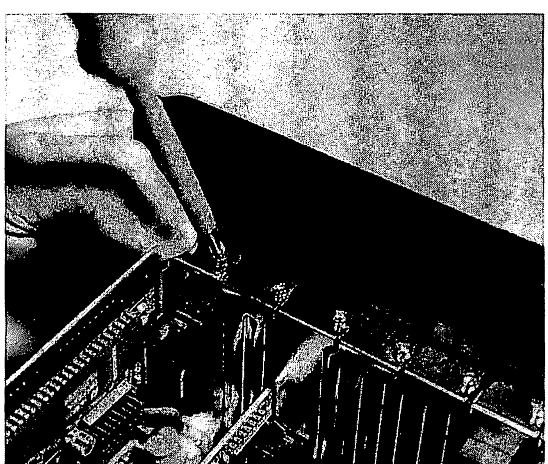
Clip the cards?

You could also use cutting pliers to snip off the pointed extension at the bottom of the card. However, before doing this, ensure that this is the reason the card is jamming. Remember that cutting the card automatically cancels any guarantee from the manufacturer.

STEP 7:

Physically install the card

Now screw the mounting bracket of the card to the back of the case. Ensure that the card remains seated. With inexpensive cases, cards sometimes become unseated. This usually occurs because of loose mounting brackets. Loosen the screws (usually there are two of them), shift the bracket to the desired position, and then tighten the screws again.



Tightening the screws on an expansion card

STEP 8:

Attach the cable

Did you forget anything?

Now connect the cable to the card (if you haven't done this already) and return any cables or other parts, which you have moved, to their original positions.

STEP 9:

Test

Perform a test on the card to see whether it works while the case is still open. That way, if you have to make any changes, you'll have an easier time getting to the parts.

STEP 10:

Close the case

Close the case in the reverse order in which you opened it.

CAUTION

When closing the case, don't let the case damage any of the cable connections.

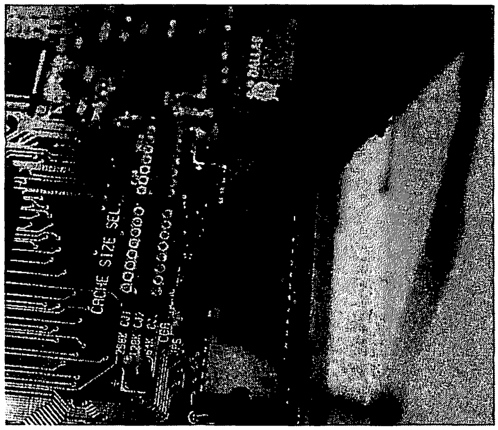
Installing/Replacing the graphics card

If you remember the following points, installing a graphics card usually isn't a problem.

Color/mono

Is the DIP switch on the motherboard positioned correctly?

With most motherboards you must set a jumper for a monochrome or color adapter. Set the mono/color jumper to the proper position. The entry for this jumper in CMOS SETUP must also correspond to the actual circumstances.

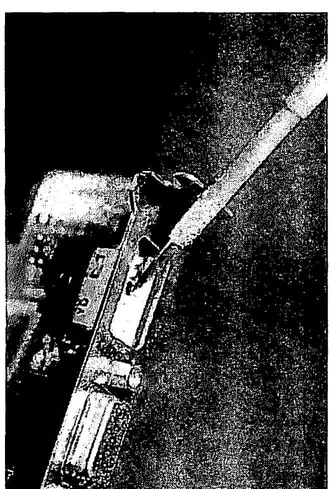


The display switch

Set the correct monitor type

Analog or TTL?

For many graphics cards, especially VGA adapters, you must set a DIP switch for the type of monitor. With VGA cards, you can also specify whether the 15-pin analog outlet or the 9-pin TTL connector is active. If your card has a switch that you can access from the back, you can even change this setting while the card is installed. However, the change won't be activated until you reboot the computer.



Setting the monitor type on the card

Is there an "interlace" jumper?

Use this jumper to set the scanning frequency for higher resolutions. You can use Super VGA cards only if your monitor is also able to reproduce the high frequency of non-interlaced mode. If you don't have a Super VGA card, set this jumper to "interlaced"; otherwise you could destroy your screen.

Watch out for the power supply

Use a slot as far away as possible from the power supply. This reduces the loss of picture quality that's caused by crosstalk from the humming of the power supply. Sometimes high frequency emissions from a neighboring network card can interfere with the picture signal. This problem can also be solved by selecting a different slot.

Address problems

Are you using an SCSI controller or a network card on your system?

SCSI address conflicts can also occur when you install a VGA card. Only a few graphics cards allow you to make changes to their BIOS address. So normally you must make this setting on the SCSI controller or network card. If you've installed software (e.g., driver software for a floppy model tape streamer) that accesses these addresses, then you must also reconfigure the software. Unfortunately, this also applies to all network software.

Use shadow RAM

If you upgrade from a Hercules compatible graphics card to an EGA or VGA adapter with its own BIOS, don't miss the speed advantage that's available by installing shadow RAM. Make the necessary entry in SETUP or load the appropriate driver in CONFIG.SYS if your CMOS SETUP doesn't allow such an entry.

Interface card installation

If you want to install a multi I/O card in your computer as the only interface card, you won't need to make any changes. By simply plugging in the card, you get one parallel port, two serial ports, and a game port. The IRQs and port addresses should match the card already.

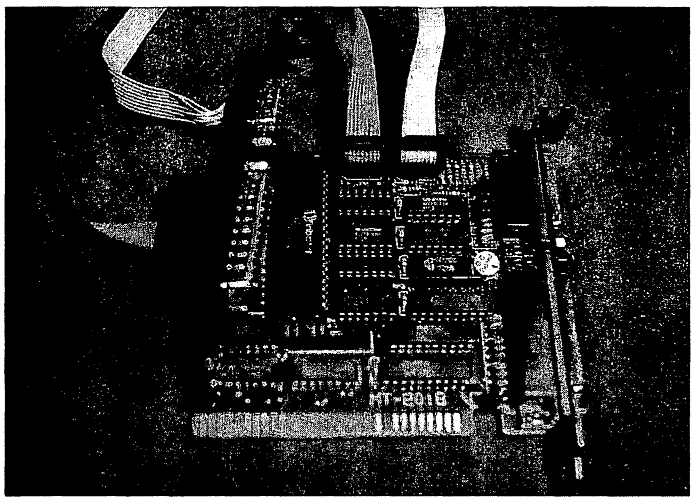
Pin 1

Be careful with cables!

The most frequent reason a serial port doesn't work is because the cable leading from the card to the back of the case isn't plugged in correctly. So, be sure that you plug in this cable properly. The marked lead of the flat ribbon cable, usually red, must match Pin 1 of the post connector.

Sometimes Pin 1 isn't marked on an interface card. In this case, first check the documentation for the interface. If you don't find any information there, maybe one of the soldered joints of the post connector on the back of the card is square, unlike all of the other joints, which are round. This soldered joint identifies it as Pin 1.

Your last resort is to experiment (there are only two possibilities) or contact the store where you purchased the card.



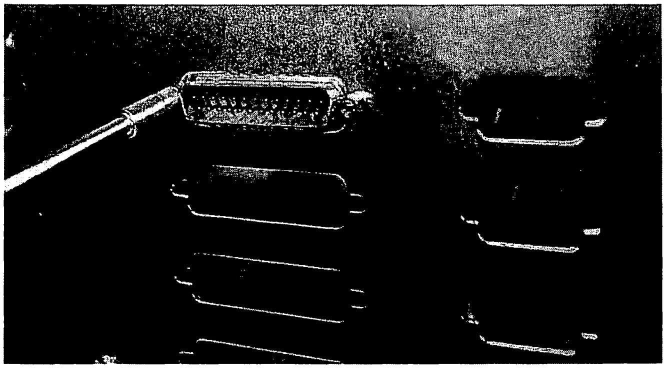
Connecting the serial interfaces correctly

Where do the cables go?

Most multi I/O cards have the connections for the printer and the game port on the mounting bracket of the card. The two serial ports have external cable connections. The plugs from these cables can either fit through holes on the back of the case or can be used together with a mounting bracket in place of a slot cover plate. This means that you won't be able to use that slot for anything else.

If you determine that you won't need the slot later, you should use the slot for this purpose. Otherwise, you'll have to remove the plug and push it through the holes in the case. To do this, use a flat or combination pliers to open the hexagon bolts.

You could also use a socket wrench if you have the right size (usually about .25 inches or 6 mm).



Tighteninig the screws

CAUTION

Be careful when you tighten the screws. Don't make the bolts too tight because the threading is made of plastic. Because of this, it's easy to strip the threading.

Maximum upgrade

In Section I we discussed the options for combining specific ports. Now we'll summarize those options.

You can easily install four serial (COM1-COM4) ports and three (LPT1-LPT3) parallel ports, as well as a GAME port (for two joysticks) in your system. If you have more than two serial ports, at least two of them must share an interrupt. Only the first printer port gets an interrupt.

One game port is enough for two

Installing a second game port isn't necessary because you can use a Y power splitter cable to connect two joysticks. Also, doing this will cause the first adapter to break down or even destroy it. To install extra ports, remember how the existing cards are set and configure the new cards so there isn't any overlapping.

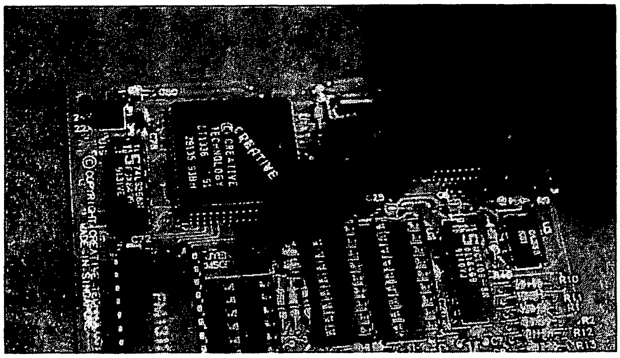
Sound card installation

The problems that occur when you install a sound card are almost related to the settings on the card itself.

Game ports

If the card has a game port but your system already has one, you must disable one of the game ports. It's best to disable the game port on the sound card, since it's readily available. Consult the

card's documentation to determine which jumper disables the game port. Sometimes the jumper itself will be marked "GAME en/dis".



Disabling the game port

Which interrupt does the card use? Printer conflicts

If the sound card uses the same interrupt as the printer port, this may lead to conflicts that could interfere with printer output or the way the sound card functions, especially if you're printing in the background from a printer spooler.

Usually the two interrupts are IRQ 5 and 7. Try to configure your printer port to use a different interrupt than your sound card. If you can't do this (e.g., because you don't have any documentation for your interface card or you don't have a test program for displaying the interrupt distribution in the system), you can also change the default value for the IRQ of the sound card.

As a result, you may have to reinstall some programs that use this interrupt. Otherwise, the programs won't run at all, especially the demo programs that are included with most cards.

Which port address does the card use? Wrong address

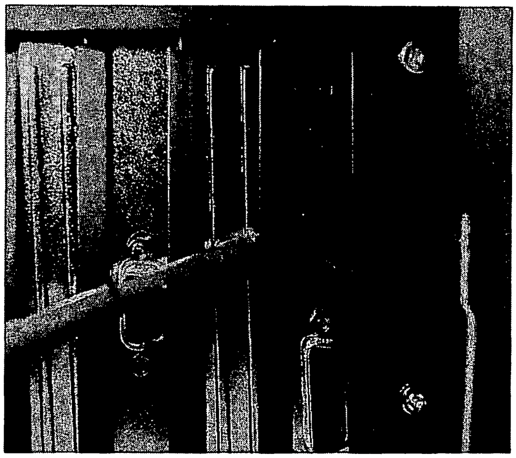
Normally the card uses address 220 Hex. If this default address is already being used by a different adapter in the system, enter a different value here. First try 240 Hex, and then try all the other possible addresses in sequence. Fortunately, conflicts with the port address rarely occur.

If you have a 486, don't be surprised if you hear unintelligible noises from the speaker instead of music, or if you get error messages about the sound card when you start certain programs.

This is a program error, not a hardware problem. Try starting the programs with the Turbo button switched off, or else disable the internal cache memory of your 486 in BIOS SETUP.

Where do I install the card? Volume control

Find a slot that provides easy access to the volume control. However, ensure that you won't damage any cable connections behind the computer.



The volume control of a sound card

Modem card installation

The modem card, or internal modem, is simply an extra serial port. Once you realize this, most of the questions you have about installing it are answered.

On which COM port should I install the card? Mouse and modem

If possible, set the modem to COM4. Otherwise, set it to COM2. If you don't use a mouse, you could also set it to COM1. The reason for this sequence is related to do the assignment of interrupts to the COM ports. We discussed this problem in Section I.

Don't set the card to a port that already exists in your computer. In other words, if you already have four serial ports, you must do without one of them by disabling it on the card when you change the setting on the jumper or by removing the card from your computer.

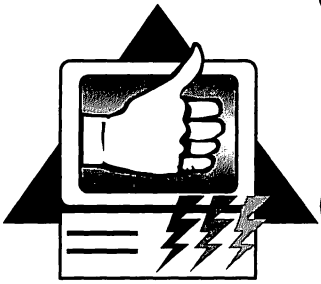
Pulse or tone dial?

Many modems give you the option of switching between pulse dialing or tone dialing. Select whatever dialing system your telephone uses.

Do you have a volume control? Is it too loud?

Some modems have an internal loudspeaker. Usually, there is a volume control on the back of the card. If you try to use the volume control, be sure to choose a slot for the modem that enables you to access the volume control easily, without having to feel your way through a jungle of cables.

CHAPTER



8 CMOS SETUP With AMI BIOS

Why SETUP?

One major advantage of an XT or AT computer is its ability to be upgraded and changed. You can select from hundreds of hard drives and use many different types of graphics cards. You can start your computer from a 5.25-inch 360K disk drive, a 3.5-inch drive at 1.44 Meg, or a network card with boot ROM.

You can add a large amount of memory to RAM or change the number of ports. Since your computer doesn't automatically recognize these changes, you must give it the opportunity to read this information.

This is the purpose of CMOS memory and SETUP. All relevant information for operating the computer is stored in CMOS memory. A battery stores this information when you switch off the computer.

You use the SETUP program to change this information. In other words, you must use this program to tell your computer about any changes you make to the hardware.

8.1 Special AMI SETUP Features

The standard

Older computers didn't have an integrated ROM SETUP program. Instead, you had to load the SETUP program from a bootable diskette. Now most computers have motherboards with an integrated ROM SETUP program.

The AMI BIOS has one of the best SETUP programs on the market today. Along with the standard settings, the AMI BIOS has many enhanced setting options that are easy to use because of AMI BIOS' menu-driven system.

Also, the AMI BIOS has become very popular because of its reliability and low price. Most motherboards now include a BIOS from American Megatrends, Inc.

Safety precautions

System doesn't react

The AMI BIOS has a security measure that reduces the chance of your making a drastic error while running the program. AMI BIOS even prevents you from making the mistake. You must confirm every important change you make in this program through a security prompt before the program executes the change.

If you are ever uncertain about how to answer the questions, press the Esc key to return to a more familiar part of the program. To exit the program without saving, simply switch off the computer.

However, the most important safety precaution in AMI SETUP is the option for ignoring the settings of advanced SETUP when you switch on the computer. To do this, hold down the Ins key when you switch on the computer until the memory test starts. Try this option first if your system doesn't react.

8.2 Running AMI SETUP

Keyboard layout

The AMI SETUP program is executed before the computer loads the operating system. Therefore, device drivers aren't installed yet. Your mouse won't work either, so you'll have to run SETUP from the keyboard.

This presents our first problem. Since whatever keyboard driver you use isn't loaded yet either, your keyboard will act like an American keyboard. This also happens when you boot up the PC without running the AUTOEXEC.BAT file. Remember this if you use a keyboard layout that's different from the American layout.

A confirmation dialog box appears every time you make a change or want to exit SETUP. Press Y to confirm this prompt. Depending on the BIOS type you have, the program either ignores any other letter or interprets it as NO.

The following table lists and describes the keys you can use in AMI SETUP. Although the keys have the same function throughout the program, certain options may not always be available.

Available keys in AMI SETUP

Key	Function
Esc	Exits
↑ ← → ↓	Selects a menu item
PgUp PgDn	Modifies the settings of an active menu item
F1	Displays a help screen for the selected menu item
F2 and F3	Change the screen colors
F5	Retrieves the settings that were in effect when you started SETUP
F6	Loads the default values in BIOS for advanced CMOS SETUP and advanced SETUP
F7	Loads the startup defaults for advanced CMOS SETUP and advanced SETUP
F10	Saves the changes and exits the program

8.3 The Main Menu

To access the main menu, press Del after BIOS completes the POST (Power On Self Test).

Take your pick!

The main menu is divided into three areas: The copyright notice, the selection menu and the help line. At the bottom of the screen, an overview of the possible key functions is displayed. Use the cursor keys to move the selection bar to the individual menu items. When a menu item is selected, the help line displays a description of the selected option. We'll give you a detailed description of each option later in this section.

Press the Ins key to execute the selected option. SETUP prompts you to press any key. Then you move to either another menu or SETUP prompts you to confirm your selection again.

8.4 STANDARD CMOS SETUP

This is probably the most important option in SETUP. In the STANDARD CMOS SETUP screen you make all the basic settings

for your computer. This menu contains the drive sizes, the hard drive parameters, RAM size, and many other settings.

NOTE

After selecting this menu item, first you'll see the warning we discussed. You can change settings in this menu that will crash your system. If this happens, hold down the Del key and switch on the computer.

Press any key to clear the warning from the screen.

You're now in the STANDARD CMOS SETUP screen. This screen is divided into six areas. The upper border displays the copyright notice. Underneath this is the actual work window. Here you can select options by pressing the cursor keys.

In the upper-right corner of this window is a small area displaying the current memory size as determined by POST. You cannot switch to this window; AMI BIOS sets the memory size automatically. A small calendar in the lower right displays the current day saved in CMOS.

To the left of the date on some systems, you'll find the Help window. A list of the possible settings for each selected menu item appears here. You don't have to press F1; the help window is always active. Below the help window, in the lower-left corner, you'll find a reference to the keys and their functions.

To modify the standard CMOS settings, select the corresponding menu item with the cursor keys. Then use PgUp and PgDn to change the settings. Choose from the following options:

Date:

Use PgUp and PgDn to change the day and the year. The day of the week is automatically displayed.

Time:

Use PgUp and PgDn to set the hours, minutes, and seconds. You can also enter the numbers directly from the keyboard.

Daylight Saving:

You can enable or disable this setting.

Hard drive types C: and D: (Hard drive C:/D: type)

This is where you define the standard type of your hard drive(s). AMI BIOS displays the parameters next to the hard drive type for you. So, if you don't know what type of hard drive you have, use the PgUp and PgDn keys to browse through the default values and find the correct hard drive type.

If you don't find the correct type among the 46 default settings, you can also enter the parameters manually. To do this, select user defined hard drive type 47 (the user defined hard drive). Then use the cursor keys to select hard drive parameter entries.

Use the numeric keys to enter the appropriate values for your hard drive:

1. Number of cylinders (Cyln)
2. Number of heads (Head)
3. Precompensation (WPcom)
4. Land zone (LZone)
5. Number of sectors (Sect)

TIP

If you don't know what to enter under points 3 and 4, we recommend entering the last track of your hard drive for land zone (i.e., the highest possible value) and either a 0 (always precompensation) or 65535 (no precompensation) for precompensation.

Sometimes it's necessary to set up two different hard drives, C: and D:, as user defined. Ami Setup also gives you this option. Hard drive type 47 for drive C: is not the same as hard drive type 47 for drive D:.

Floppy drives A: and B:

Enter the installed drive type here. Use the PgUp and PgDn keys to make your entry. The information you enter here must be correct; otherwise you may no longer be able to boot from a diskette.

Primary display:

Monochrome color

Enter the graphics card installed on your system here. If you have a Hercules (compatible) card, select "Monochrome". If you have a monochrome VGA screen, use the VGA/PGA/EGA option.

The Color 40x25 or 80x25 settings are for a CGA card. However, these settings will also usually work with an EGA/VGA card without producing an error message. You won't have any trouble with graphic output until later. Select this option only if you actually have a CGA card installed. The numbers refer to the number of characters that can be displayed in text mode.

Keyboard:

You can choose between switching off the keyboard test here. If you enter "Not installed", the POST won't perform the keyboard test. This will speed up the system start.

8.5 ADVANCED CMOS SETUP

ADVANCED CMOS SETUP is one of the special features of the AMI BIOS. Use ADVANCED CMOS SETUP to make settings independent from the chip set of the motherboard. Unfortunately, the layout of this menu item varies from computer to computer. It's possible you won't find every menu item of your BIOS in the list discussed below. In these instances, press F1 for the AMI BIOS Help system.

Special functions

After reading the usual warning, you'll move to the ADVANCED CMOS SETUP screen. Most options can be enabled or disabled. Some items have more than two settings.

Setting typematic frequency

If you hold down a key on your keyboard, the character is repeated after a certain delay on the screen. If you set this option to Enabled, then you can set the delay from the "Typematic Rate Delay (msec)" menu item and you can set the speed of the

character repetition from the "Typematic Rate (Chars/Sec)" menu item.

Above 1 MB memory test

If your system takes too long to start up and you don't want to press Esc to skip the memory test (pressing Esc takes you to SETUP on some computers), then you can skip the test for memory above 1 Meg by setting this option to "Disabled".

Memory test tick sound

Set this option to "Disabled" if the ticking bothers you.

Memory parity error check

Enter "Disabled" here if you don't want the computer to check the parity bits.

TIP

Since this isn't practical, you should keep it set at "Enabled".

Press Del message display

Choose "Disabled" for this setting if you don't want the message to appear on the screen when you boot the computer.

Hard drive type 47 RAM area

AMI BIOS requires 1K of RAM for the user-defined hard drives (type 47). Use this option to determine whether this area should be in base system memory at 0:300 Hex, or in free DOS memory. Choose free DOS memory only if the base system memory is already occupied.

Wait for F1 if any errors

This setting determines whether the boot process should be interrupted until you press F1 if POST finds an error. Set this option to "Disabled" only if you are unable to eliminate an error but the system is still running.

System bootup Num Lock

Ordinarily, the external numeric keypad is set to numeric display when you boot the system. Set this option to "Disabled" if you don't want the keypad to be set to numeric display.

Numeric processor

Not all Setup programs have this option. If your computer cannot perform this setting automatically, then set "Present" if you have a WEITEK coprocessor.

Weitek processor

The POST cannot recognize the existence of an EK processor. If you installed an EK processor in your system, set this option to "Present".

Floppy Drive Seek At Boot

Set this option to "Disabled" to remove the typical boot-up noise. It also saves you time in the system test.

System Boot Up Sequence

Normally, the computer first tries to boot from the diskette. If a system diskette isn't in the drive, the computer tries to boot from the hard drive. Today, most computers start from the hard drive. So if you set this option to "C:,A:", you'll speed up the process while also protecting your computer from unauthorized access.

External/internal cache memory

Choose "Disabled" to slow down your computer, or if you have problems with expansion cards.

Password checking option

You can choose to have the computer prompt for the password every time you start up the system ("Always"), or only when you enter Setup ("Setup"). Select "Disabled" to remove the password prompt.

Turbo video mode

You'll occasionally find this option on some newer motherboards. Because Turbo Video Mode is set to "Disabled" by default, picture construction under MS-DOS is extremely slow. If your SETUP program has this function, be sure to set it to "Enabled".

Video ROM shadow C000, 16K

Use this option to copy the ROM-BIOS in the system to the root directory extension. This significantly speeds up your PC system. You should definitely set the Video and System ROM shadow to "Enabled". The Adapter ROM Shadow only makes sense if you have an adapter with BIOS. In these instances, enable only the address area that matches the address of your adapter ROM. For example, for a hard drive controller this area is usually at C800.

8.6 ADVANCED CHIPSET SETUP

The options of this menu depend on the chipset used on the motherboard. The options may appear differently on your computer, or may not appear at all. Since it would be impossible for us to cover all the versions of chipsets, press F1 for Help.

TIP

Usually, the options of advanced chipset setup do more damage than good. If you aren't certain about the purpose of an option, press / to accept the default setting.

Hidden refresh

Set this option to "Enabled" to have the computer perform a RAM refresh without pausing the CPU. Sometimes the computer succeeds, but usually this option causes problems. We recommend leaving the option set to "Disabled" because the advantage in speed is only minimal.

ATBUS slow refresh

Choose "Enabled" for this setting to perform the RAM refresh only every fourth time.

AT cycle wait state

Enter "Enabled" here to add another wait state to the AT Bus. Sometimes this is a way to solve problems with older expansion cards.

DRAM read/write wait state

This setting allows you to choose from 0 to 3 wait states for read and write accesses. This setting depends on the access time of your RAMs and the recommendations in the manual for your motherboard.

TIP

If you encounter memory problems (PARITY ERROR) while running your computer, try to solve the problem by setting all the wait states to their highest values.

Cache write W/S

Normally you can run static RAM of cache memory without wait states. The only time you must assign a wait state ("1W/S") is with the 40ns SRAM chips, which are rarely used.

8.7 Auto Configuration with BIOS DEFAULTS

These options are part of the security functions provided by the AMI BIOS.

Use the first option, BIOS DEFAULTS, to set all the parameters of advanced SETUP back to their old values (i.e., the values stored in CMOS before you loaded the Setup program). For example, this option is useful when you make changes to settings and then decide you want to return to the old settings but you can't remember them.

Harmless defaults

The second option, POWER ON DEFAULTS, loads specific settings from a list in the BIOS ROM. Use this option to set all the parameters of advanced SETUP functions to harmless values (e.g., if the computer is no longer able to load its operating system, or if other disturbances occur during operation that could be related to the SETUP configuration).

TIP

We recommend running this option before changing any settings of advanced Setup when you configure your motherboard for the first time. Frequently, even new motherboards have several possible changes available in advanced Setup that can result in computer crashes.

Because both options are protected by a security prompt, you must press Y to confirm them again before they can be activated.

Then, select WRITE TO CMOS AND EXIT to quit SETUP.

8.8 CHANGE PASSWORD

After you activate the menu item for changing the password, the program prompts you to enter the current password: ENTER CURRENT PASSWORD. If you haven't used a password before, the default password is "AMI".

Notice that your keystrokes won't appear as letters on the screen. Remember, no one else is supposed to know your password. After you enter the correct password, the program prompts you for the password: ENTER NEW PASSWORD.

Now enter the new password, which can contain up to six letters, and press the Enter key. The program then prompts you to enter the new password again with the following message:

RE-ENTER NEW PASSWORD

This is for your own security. If you make a mistake typing in the new password, an error message is displayed:

ERROR...

Then you'll return to the main menu. You can try again from here at any time.

8.9 HARD DISK UTILITY

This program lets you perform a low-level format on your hard drive, run a surface test, and set the interleave ratio. Each of these processes irretrievably destroys the data on your hard drive.

WARNING

Special warning to AT-BUS hard drive users

Avoid this option if you have data on your hard drive that aren't backed up or you aren't certain whether you have an AT-bus hard drive installed in your computer (AT bus hard drives cannot be low-level formatted).

If you don't have other software to perform this task, use this formatting routine only if you have an MFM or RLL hard drive. We recommend using this program very carefully.

Since all versions of AMI BIOS aren't identical, a separate chapter is needed to thoroughly describe all the different options. We already talked about low-level formatting in the chapter on installing hard drives.

First, compare the hard drive parameters in the top half of the screen with the parameters of the hard drive installed on your computer. You can change these settings through standard CMOS Setup. Next, select the Hard Disk Format option and answer all the questions. Enter any bad tracks in the appropriate window and confirm the security prompt by pressing "Y".

8.10 Quitting Setup

You can exit the SETUP program with or without saving the changes you made.

To exit SETUP:

1. To save your changes, either select WRITE TO CMOS AND EXIT or press F10. Then, SETUP asks you whether you really want to save the changes and exit the program:

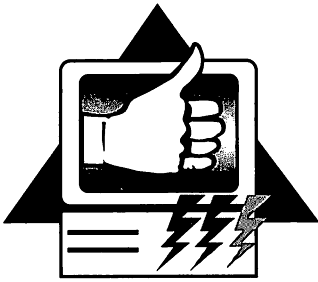
   Write to CMOS and Exit (Y/N) ? N

   The default response is "N". Change it to "Y" and press Enter. The Setup program now writes your entries to the CMOS and, if everything is correct, the computer will run properly.

2. To exit SETUP without saving the changes, either select "DO NOT WRITE TO CMOS AND EXIT" or press Esc. Once again, you have to answer a security prompt:

   Want to Quit Without Saving (Y/N) ? N

   The default value is "N". Select "Y" and then Enter to exit SETUP.



CHAPTER

9 Build Your Own Multimedia PC

Now that we've described most of the components in a PC system, in this chapter we'll discuss how you can build a complete computer.

This chapter shows how to assemble your own modern, versatile, powerful PC from scratch to software installation. We cannot discuss all the problems that you might encounter. However, by following our example, you should be able to follow the process of building your own PC.

Refer to other chapters (especially Chapter 11) for troubleshooting information.

9.1 Multimedia Explained

Everybody's talking about multimedia

Although Multimedia may sound like a completely new trend in computing, it has been with us for a long time. The term first appeared in education during the 1960s and 1970s, when it described new media supporting the learning process in classroom instruction. Now, it involves integrating different applications of entertainment electronics such as video, sound, and graphics.

Many articles and books are currently being written about this subject. After a slow start, PCs (both DOS and Windows) are now "multimedia capable." Previously, only a few complex applications were multimedia capable.

The components deliver information in a variety of ways, but achieve their greatest effectiveness through their interaction. Information, images and sounds are technically and aesthetically integrated, then focused on a single product.

New dimension in the 90s

Today the term multimedia has gained a new dimension. Unlike many other areas of computing, multimedia suffers not from the fact that few people understand it, but rather that everyone understands it differently.

The manufacturers should take responsibility for this because few standards exist between products. Any departure from traditional word processing and number crunching is immediately labeled multimedia.

The MPC definition

The Multimedia PC Marketing Council, consisting of Microsoft and other leading hardware and software manufacturers, published a multimedia standard in a text called the Red Book.

This standard was intended to apply to future developments in PC multimedia. The Windows graphical interface forms the foundation of this standard, enhanced by multimedia software components and programming tools.

Initially the Microsoft Windows Multimedia Extension provided the software interface to Windows 3.0 for multimedia products from a variety of manufacturers. The corresponding multimedia drivers and interfaces have since been incorporated into Windows 3.1.

MPC as a marketing symbol

Using CD-ROM drives for memory-intensive graphics and sound file processing places rigorous demands on PC hardware. Both sound cards and CD-ROMs are specified as components of the Multimedia PC (MPC) standard.

A PC configuration must include all components and meet all specifications defined in the standard to qualify for the MPC seal.

MPC
Multimedia PC

The MPC seal

Hardware manufacturers wishing to submit their products for MPC approval must apply to the Multimedia PC Marketing Council in New York. Approval certifies that the product fulfills the requirements of the MPC standard.

The MPC standard

A personal computer system that has qualified for the MPC title has specific characteristics that make it suitable for multimedia use.

The MPC standard, started by Microsoft and others, attempts to set the first standards for personal computers capable of sound and video through hardware and software ports.

The initial standard adopted by the Multimedia PC Marketing Council was modest enough so owners of Intel 80286 based computers could enjoy the benefits of multimedia.

Although the following specifications were later upgraded, they formed the first definition of the MPC standard:

First MPC standard

- 80286 based PC
- Minimum 10 MHz clock speed
- 2 Meg main memory (RAM), configured as extended memory
- 30 Meg hard drive capacity
- 1.44 Meg 3.5-inch disk drive
- 101-key IBM keyboard
- Serial interface (9-pin or 25-pin), programmable up to 9600 baud, selectable without interrupts
- Parallel interface (25-pin)
- VGA card and monitor with 640 x 480 pixel resolution, 16 colors

- Mouse (2-button)
- Analog joystick port (IBM-compatible)
- MIDI port
- MPC-compatible sound card
- MPC-compatible CD-ROM drive
- System software compatible with Microsoft Windows Multimedia Extension

It soon became apparent, however, that basing the multimedia specification on the Microsoft Windows platform would lead to performance problems on the system described.

Current MPC standard

The MPC standard has changed so there is now two levels. The MPC level 1 standard (introduced in 1990) now includes the following specifications:

- 386 or higher
- 80386SX based PC
- Minimum 16 MHz clock speed
- 2 Meg main memory (RAM), configured as extended memory
- 30 Meg hard drive capacity
- 1.44 Meg 3.5-inch disk drive
- 101-key IBM keyboard
- Serial interface (9-pin or 25-pin), programmable up to 9600 baud, selectable without interrupts
- Parallel interface (25-pin)
- VGA card and monitor with 640 x 480 pixel resolution, 256 colors; or 800 x 600 pixel resolution, 16 colors

- Mouse (2-button)
- Analog joystick port (IBM-compatible)
- MIDI port
- MPC-compatible sound card
- MPC-compatible CD-ROM drive
- System software compatible with Microsoft Windows Multimedia Extension

NOTE

The MPC logo does not guarantee the quality of the products, only that the products have met the specifications of the MPC Council. Therefore, you should look for the MPC specifications and not necessarily the MPC logo when shopping for a multimedia system.

MPC Level 2

Most applications will run faster on the MPC2 platform, introduced in May, 1993. These changes reflect the changes in technology since the MPC Level 1 was published. Software based video will perform better on Level 2 Multimedia PCs. Also, photo CD applications which are not supported on base Level 1 MPCs will run better on Level 2 machines.

- 486SX 25
- Minimum 25 MHz clock speed
- 4 Meg main memory (RAM), configured as extended memory
- 160 Meg hard drive capacity
- 1.44 Meg 3.5-inch disk drive
- Serial interface (9-pin or 25-pin), 9600 bps

- Parallel interface (bidirectional)
- VGA card and monitor with 640 x 480 pixel resolution, 256 colors; or 800 x 600 pixel resolution, 16 colors
- Mouse (2-button)
- Analog joystick port (IBM-compatible)
- MIDI port
- MPC-compatible sound card (16-bit DAC and ADC)
- MPC-compatible CD-ROM drive (300K/sec transfer rate, 400ms or less seek time, 10,000 hours MTBF, CD-ROM XA ready, multisession capable, subchannel Q)
- System software compatible with Microsoft Windows Multimedia Extension and Microsoft Windows 3.1

Configuration

The technology for connecting video recorders, cameras, and televisions to PCs is constantly changing and no true standards yet exist. So we'll describe how to assemble a custom PC outfitted with a CD-ROM drive and a digital audio system. According to Multimedia PC specifications, this is a "Multimedia PC."

Hardware

- Big tower case
- Motherboard with 486DX processor, 33 MHz system clock
- 4 Meg RAM
- 5.25-inch disk drive
- 3.5-inch disk drive
- 120 Meg hard drive with IDE port, 64K cache
- AT bus combination controller with integrated I/O functions (1 parallel, 2 serial ports, 1 joystick connection)

- VGA 16-bit video card with ET4000 chip and 1 Meg video RAM
- Sound Blaster Pro sound card (Creative Labs)
- 5.25-inch CD-ROM internal drive
- MF/2 keyboard
- Serial Microsoft compatible mouse
- VGA 14" color monitor, 0.28mm dot pitch, max. resolution 1024x768
- 1 pair audio stereo speakers with connecting cable

Software

- Operating system: MS-DOS, Version 5.0
- User interface: Microsoft Windows, Version 3.1

First we'll list the steps involved in building your own multimedia PC. Take enough time to do all the steps in sequence. It should take a minimum of two to four hours to perform all the steps, depending on your experience and ability.

We assume that you have all the necessary equipment, including the documentation and software for these components. You also must have the original diskettes for the software and operating system you're going to install.

NOTE

Be sure to read or reread Chapter 6, which contains information on the rules and dangers of working on PCs.

Hardware and software installation in 29 steps

The following is a list of the 29 steps for building your own multimedia PC:

1. Ensure that you have all the components, software, and documentation
2. Open and prepare the case
3. Equip motherboard with memory module chips
4. Test the motherboard, memory, and video card outside of the case
5. Install motherboard in case
6. Install video card
7. Test motherboard, memory, and video card inside case
8. Install combination controller with ports
9. Plug in disk drive A: and test
10. Plug in disk drive B: and test
11. Install disk drives and tighten screws
12. Plug in hard drive and set it up
13. Partition, format, and test hard drive
14. Install hard drive and tighten screws
15. Install DOS on the hard drive
16. Make manual changes to start and configuration files
17. Install Windows 3.1 on the hard drive
18. Install video card driver software
19. Prepare sound card
20. Install sound card
21. Connect external speakers
22. Install software for sound card
23. Try out sound card

24. Link sound card to Windows 3.1 and test
25. Connect CD-ROM drive
26. Set up CD-ROM drive under DOS
27. Try out CD-ROM drive
28. Install CD-ROM drive and tighten screws
29. Close case

NOTE

You can stop after step 17 or 18 if you don't want the multimedia options. This gives you a complete, custom built 486 system, configured as above except without the sound card and CD-ROM drive.

As soon as you have all the components and a place to work, you're ready to start.

STEP 1:

Check the components, documentation, and software

Start by ensuring that all the necessary components are available. Remember that the components must be complete.

Materials

- Big tower case

The tower case comes with case faceplates, a key for the keyboard lock, a bag with spacers and mounting screws, a PC loudspeaker, documentation of the settings for the digital speed display, and a power cable (the accessories are usually in a small cardboard box inside the case).

- Motherboard with 486DX-33 CPU

The motherboard comes with at least 64K SRAM modules for external cache, sockets for at least 8 SIMM modules, current BIOS (1991 at the earliest), and technical documentation.

- 4 SIMM modules

Each with 1 Meg capacity, 70 ns access time.

- 5.25-inch disk drive
- 3.5-inch disk drive
- A 5.25-inch mounting kit with mounting screws
- AT bus combination controller with ports

This includes an AT bus 16-bit controller card with one parallel and joystick port on the cover plate, 1 additional case cover plate with two mounted serial sockets (9-pin and 25-pin) with two 10-line connector cables, one flat ribbon cable for disk drives (34-line) with two plugs per drive position, one end twisted, 1 flat ribbon cable for hard drive connection (40-line), and technical documentation.

- Hard drive with IDE port

3.5-inch format, 120 Meg capacity, Conner Model CP30104

- VGA video card with ET4000 chip

This includes 1 Meg RAM, various driver diskettes, and technical documentation.

- Sound card

Sound Blaster Pro model from Creative Labs comes with 1 cable for stereo, various diskettes, and technical documentation.

- 1 pair stereo speakers (amplified is best)

With connecting cable.

- CD-ROM drive

Internal drive from Matsushita. Comes with 1 flat ribbon cable for connection to the CD-ROM controller on the sound card, various

diskettes, 1 compact disk in the caddy, 1 cable for the audio input of the sound card, and technical documentation.

- 102 key keyboard, MF/2 format

- Serial Microsoft compatible mouse

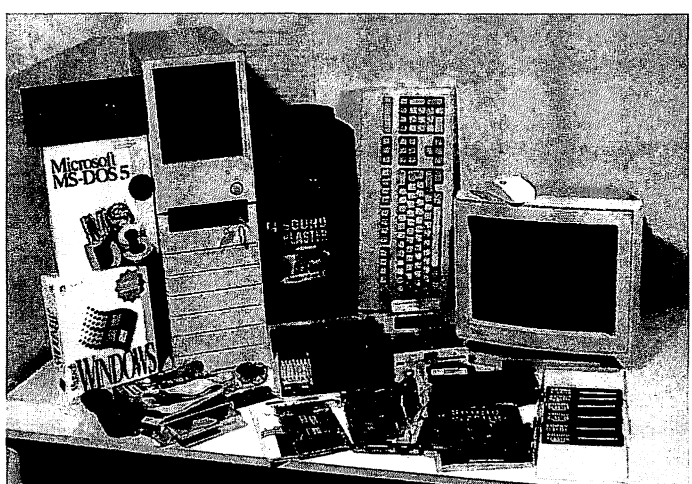
This includes a driver diskette that can't be used under Windows 3.1. Frequently also comes with additional software, a mouse pad or an adapter for a 25-pin connection.

- 14" analog color monitor

Dot pitch 0.28mm, frequency band 31.5-35.5 KHz, max. resolution 1024x768 pixels, glare free CRT, cable for connection to the PC, and power cable.

- MS-DOS 5.0 or 6.x

This includes various diskettes and program documentation. For this project, make sure you create a bootable diskette (see Chapter 7 for more information).



The multimedia PC consists of many parts

This diskette should contain FORMAT, FDISK, COMMAND.COM, and whatever you might need to format hard drives and other disks. In this chapter, we'll call this the FAILSAFE diskette.

- Microsoft Windows 3.1

This includes various diskettes and program documentation.

- A data CD of your choice for testing purposes

If you have everything on our list, combine all the technical documentation in one pile. Later, you won't have to look for the information you need.

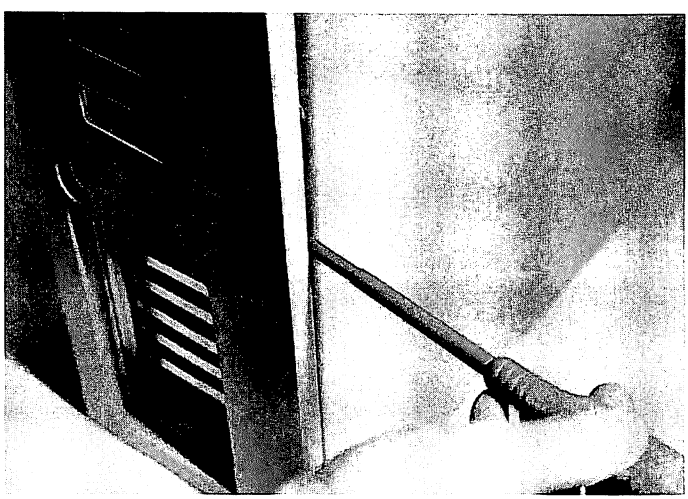
Also, keep the software and the components together so they don't get lost.

STEP 2:

Open and prepare the case

After taking the tower case out of the package, place it on your worktable, with the back facing you. You won't always be able to access the case screws right away.

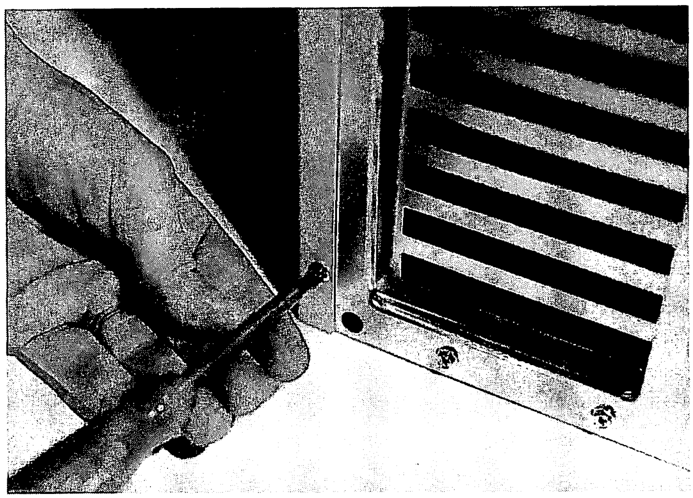
Frequently, you must first use a screwdriver to pry off a plastic cover from the back of the case.



Removing the plastic cover from the back of the case

Then use a Phillips head screwdriver to unscrew the six case screws, which are in each of the four corners and in between the top and bottom corners on the left and right.

So you don't misplace them, place all the screws in a small cup.

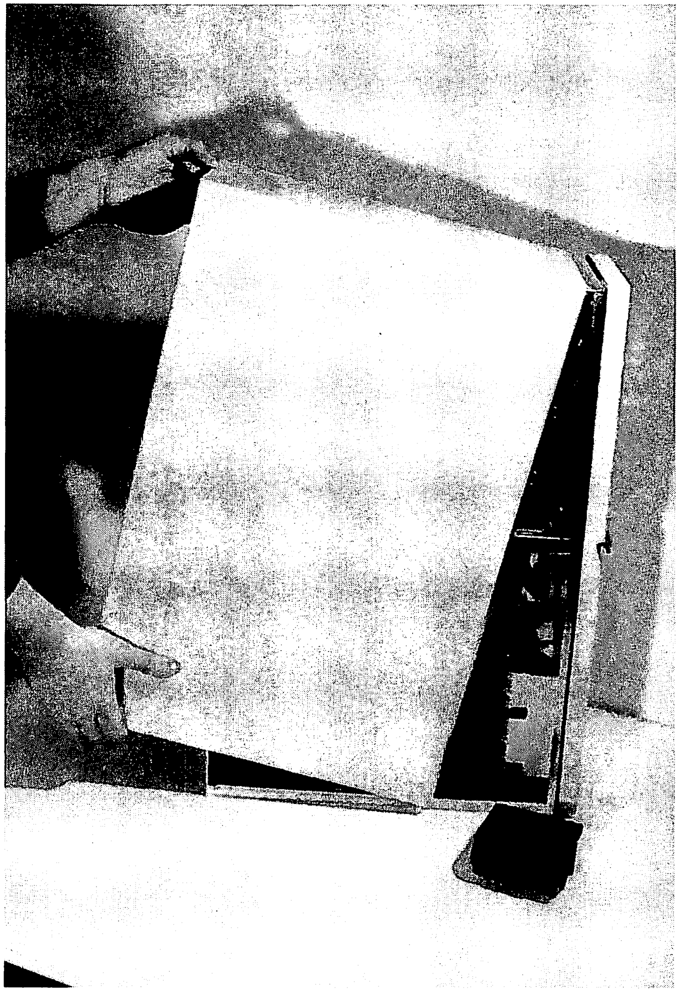


Unscrewing the case

After unscrewing the case, you'll be able to pull up the cover of the case. Inside the case is a small carton containing the accessories.

These accessories include a small bag containing screws and spacers, several plastic guide rails, and other items. We'll discuss all the accessories later.

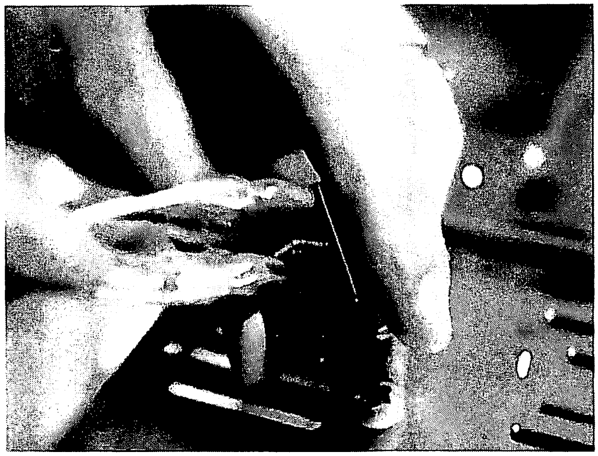
Set the carton aside for now.



Removing the cover from the case

Connecting the power switch

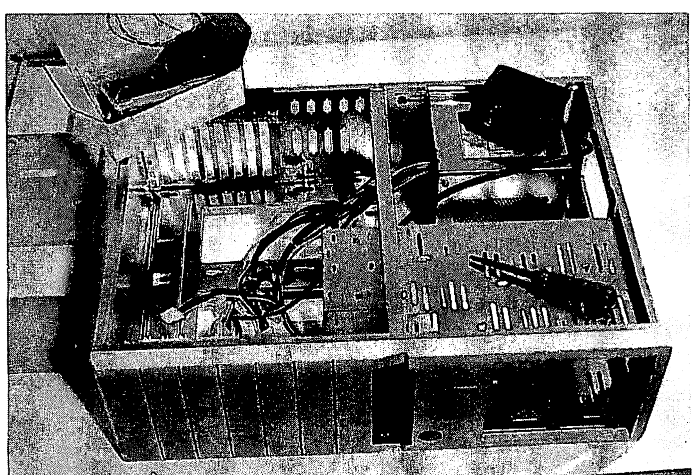
For the tower case in our example, you must connect the power switch with the cable harness from the power supply first. Check your case and power supply documentation for more information.



One type of power switch connection

Now that you've connected the power switch with the power supply unit, move the case to a comfortable working position. Place the tower on the table with the front facing you and the mounting brackets for the drives on the right hand side. Next, find the carton with the case accessories.

Inside the carton you should find a small bag containing screws and spacers.



Easier access to the tower

Place the contents of this bag into the cup you're using to hold the screws. Set the case faceplates aside for now; you'll install them last. The bag should also contain several plastic guide rails. These rails are designed for longer boards. Mount these rails across from the grooves for the expansion slots by clamping them into the pre-drilled holes with the plastic slots.

You won't need the rest of the contents of the carton until later. Move the carton out of the way for now.

The case accessories

STEP 3:

Equipping the motherboard with SIMM modules

Now that you've got the case ready to receive different components, plug the memory modules into the motherboard.

NOTE

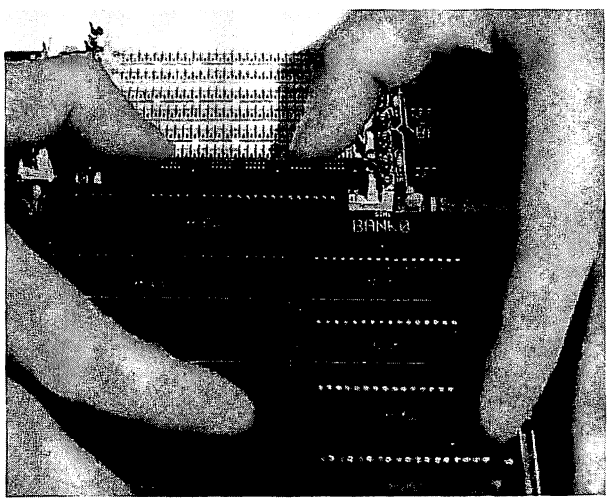
Touch the tower case before touching the motherboard and the memory modules to discharge any static charges that may have built up in your body.

Filling up bank 0

Now take the motherboard from the package and place it flat on a non-conducting material (i.e., a piece of foam). Refer to the documentation or the label on the board to determine which of the eight SIMM sockets is bank 0. Now plug in one of the four 1 Meg SIMM modules in each of the four sockets of bank 0.

Unless you use force, there's no chance of plugging the modules in incorrectly. Make certain that each module is in full contact with the sockets and rock them back and forth until the clips lock in place.

Step 3 is completed when you finish installing the four modules in the plan.



Installing the SIMM modules

STEP 4:

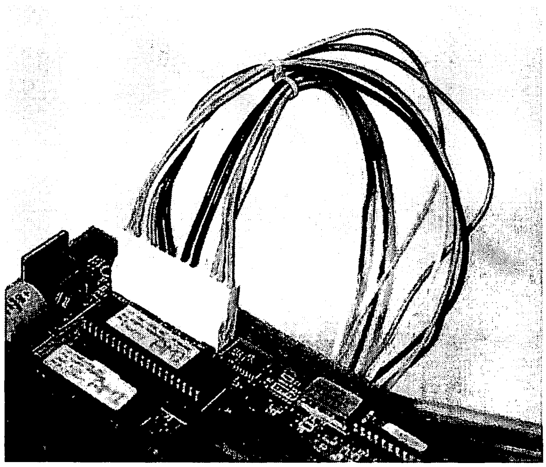
Testing the motherboard, memory and video card outside of the case

Test first - then tighten the screws!

To avoid problems later, test the memory installation and the motherboard now to see whether they work. Place the motherboard with the installed memory on the non-conducting material. Then place the non-conducting material on the open PC case so you can easily plug in the motherboard connection cable from the power supply to the connection on the motherboard.

The motherboard gets its power from the two plugs marked "P8" and "P9" from the PC power supply unit. These two plugs are easy to recognize because, unlike other cables from the PC power supply unit, they have six leads each.

The plugs are connected to the motherboard so the three red cables next to one another point to the middle of the board, while the only orange or white cable is at the keyboard input. It's impossible to plug the boards in wrong.



The board plugs of the power supply unit

If you mix up the plugs, the motherboard won't work. However, mixing up the plugs shouldn't result in a short circuit.

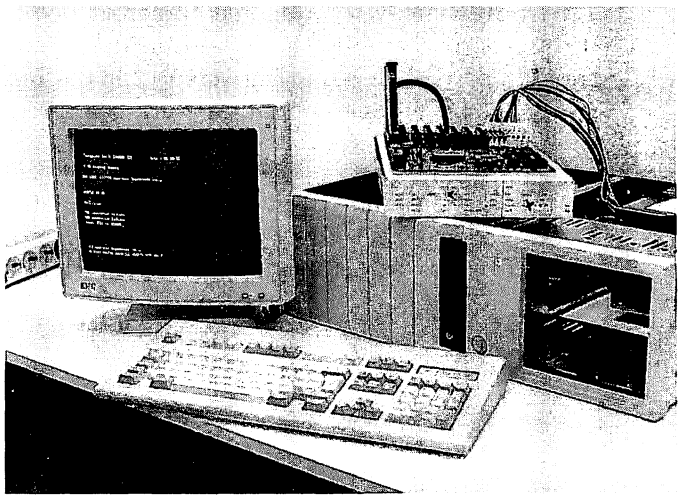
Don't forget the video card

You'll also need the video card for your test. Take it out of the package and insert it in one of the expansion slots on the motherboard.

> **NOTE**
>
> Be careful when you insert the video card, since the motherboard isn't screwed in yet. Don't use force either. Make sure that the case faceplate of the video card doesn't lift up the motherboard.

Now connect the monitor with the video card and plug the keyboard into the motherboard. Finally, connect the PC with a

power cable and then plug it into an outlet. Make certain that the power switch is set to "off".



Main board ready for testing

Recognizing the correct amount of memory

Check all the connections you just made. Is the video card inserted properly in the slot? Is the motherboard connected with the power supply unit? It's very important the motherboard doesn't touch any metal.

Now switch on both the PC and the monitor. After a moment, the BIOS of the video card and then the system BIOS appear on the screen. Then the computer performs the autostart routine, counting 4096K of memory. Everything is all right if the computer displays an amount between 3712K and 4096K.

You can ignore the error messages following the memory test. We only needed to test whether the motherboard and video card worked and that the computer recognized the correct amount of memory.

Now switch off the power and unplug the power cable. Unplug everything again, pull the video card from the slot and disconnect the motherboard from the power supply. This step is finished.

STEP 5:

Install the motherboard and tighten the screws

Since you're certain the motherboard and the installed memory work properly, you can begin installing these components.

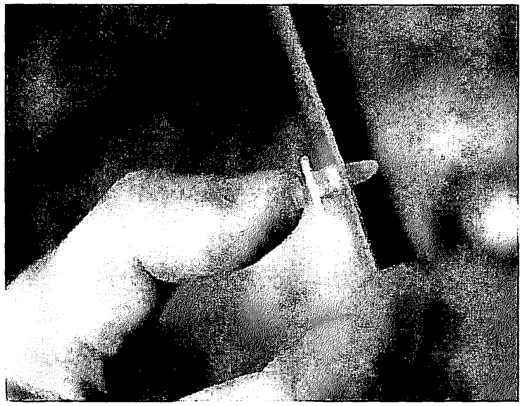
First, screw in two hexagonal threaded bolts (from the bag of screws accompanying the case) into the mounting plate for the motherboard. The mounting screws for the motherboard fit into these bolts. The case mounting plate has threaded holes for this purpose.

Place the motherboard on the mounting plate to check whether the threaded holes of both parts match. Then use a small socket wrench to screw the threaded bolts in the right holes.

Screwing the threaded bolts into the case

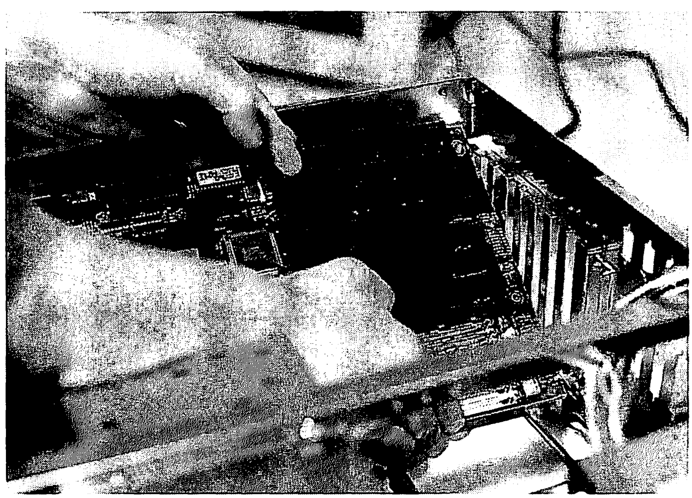
Spacers

Then put the plastic spacers on the motherboard (also in the bag of screws) that will later screw into the guide holes on the mounting plate of the case. Insert the spacers into the threaded holes that cover the guide holes from the bottom of the board with the pointed end up. After you finish inserting all the necessary spacers, you're ready to insert the motherboard.



Inserting the spacers

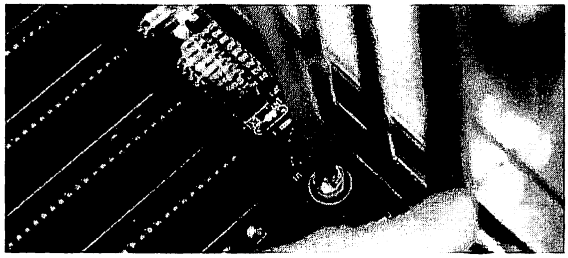
Insert the board with the spacers in the guide holes and then move the board slightly to the right, until the holes are covered by the threaded bolts. Use two screws to fasten the motherboard to the case. Turn the screws carefully; it's enough if the motherboard no longer slips. Finally, plug the power cables from the power unit into the board, as you did in the last step.



Inserting the board

The central component, the motherboard, is now in the case. Consult the documentation to ensure that the jumpers and switches are set correctly.

Now is the time to check because you still have free access. Later, when the case is full, it will be more difficult to find the jumpers and change the settings.



Tightening the screws on the motherboard

STEP 6:

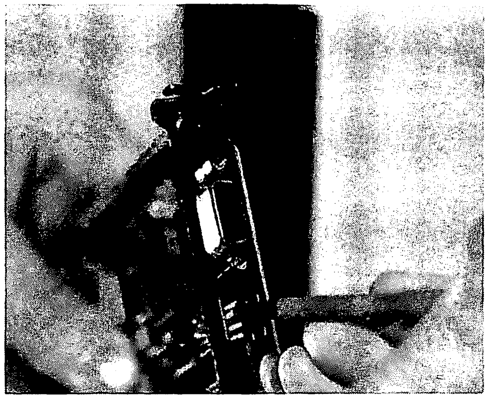
Install video card and tighten screws

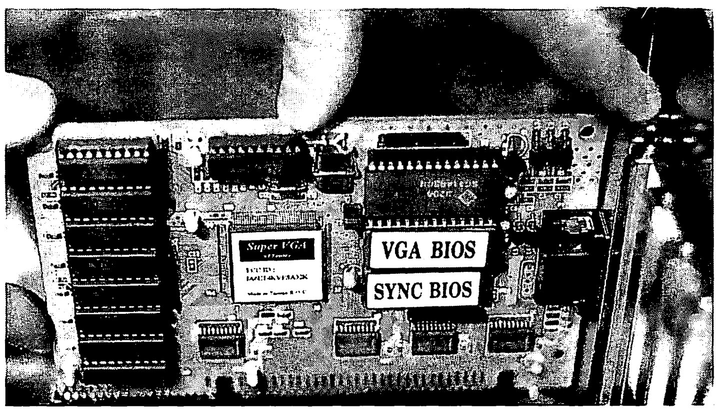
The display switch of the motherboard

Next, we'll reinsert the video card. Compare the settings of the jumpers or switches on the card with the documentation accompanying the video card. Often you must set the correct monitor type. You can install the card once it has the proper settings. Find a 16-bit slot as far to the left as possible.

Since you won't need to cable the video card to other components of the PC, install it a little farther to the left. Plug the video card into a 16-bit slot and screw it to the back of the case. Now you can set the display switch on the motherboard.

The display switch is either a jumper that you have to set or a switch on a DIP switch block. The documentation of the motherboard contains this information. Set the display switch to color.





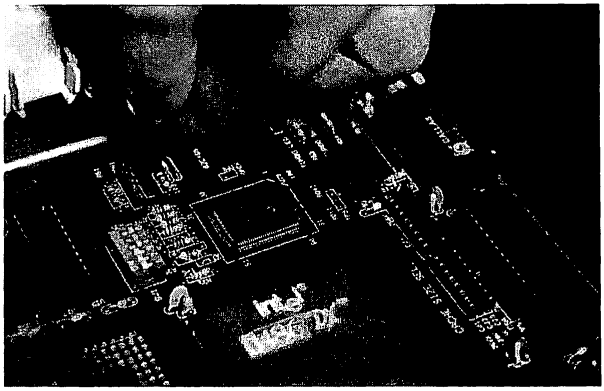
Configuring and inserting the video card

STEP 7:

Test the motherboard, memory and video card inside the case

After you screw in the motherboard and the video card, connect the PC speaker. Its beeping will help you when you're troubleshooting. The two-lead cable (usually red and black or yellow and black) from the PC loudspeaker ends in a four-pin plug; only the outer pins are used.

The motherboard has its counterpart, a four-pin strip that is often marked "SPK" (for speaker). Your motherboard documentation should provide detailed information about where this connection is located. Find it and plug in the loudspeaker cable.



Connecting the speaker

An intermediate test

Next we'll perform an intermediate test to detect possible errors as early as possible. When you install the motherboard, there's a chance that the case could be touching it somewhere, resulting in a short circuit. Your motherboard won't work after a short circuit. So let's reconnect all the cables between the PC, monitor, and keyboard and get ready to switch on the PC. Remember to plug the PC back into the power supply.

Check the motherboard for screws you may have forgotten. As soon as everything seems to be in order, switch on the PC.

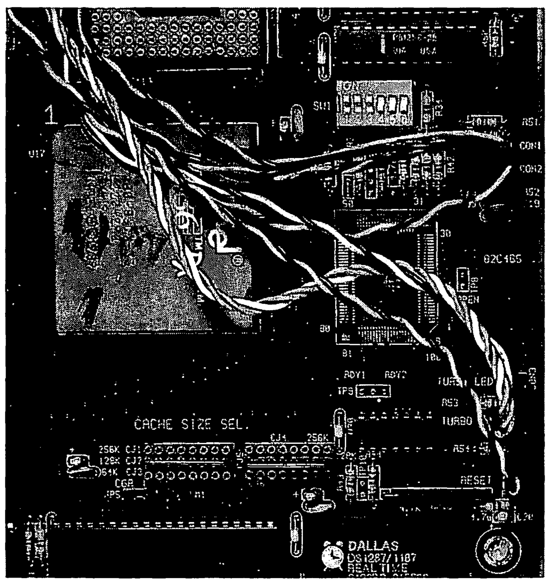
The PC system displays the video card BIOS and system BIOS messages on the screen. Now, since you hooked up the speaker, you should be able to hear the PC counting the memory. If you don't do anything else, the computer will then check the configuration and you won't see anything else on the screen.

When the computer finishes checking, you'll probably hear a beep and see an error message on the screen, listing errors or prompting you to press a key. For now we won't worry about error messages. Instead, we'll connect the cables of the case. First, switch off your PC.

Colored cables - clever buttons

First, connect the Reset button to the motherboard. Find the cable leading from the Reset button on the front of the case. This is a two-lead cable that's usually blue and white. You should be able to find its counterpart on the motherboard, a pin strip with two pins. Often the Reset connection is labeled "RST" for Reset or "HWR" for hardware reset.

Next, find the cable for both the power LED and the keyboard lock. Both functions are usually on a combined connection on the motherboard. The connector has five pins, unlike any of the other connectors. However, only four of the five pins are occupied. Usually the plug is also combined and has five pins. One position is missing. One of the cables is usually green; it's the cable you connect to the connector pin marked "1" on the motherboard connection.



Connecting the Reset button, Turbo button, keyboard lock, and LED

In rare cases, the connection cables aren't combined into a 5-pin plug. If you don't have a combination plug, remember that the power LED cable is usually green and white. The two cables fit into the outer pins, with green going on Pin 1. The two-pin cable from the keyboard lock goes in between, and one pin is free. We'll find out which one later when we test the keyboard lock.

"Turbo"

We still must find the cable for the Turbo switch. Usually the cable is three-pin (black-white-orange), but you almost always connect it to a two-pin connector on the motherboard.

The connector on the motherboard is marked "Turbo-SW" or "TB". Depending on whether this switch sets the board to maximum frequency when closed or open, the factory may already have put a

jumper on the connector pins. This automatically sets the PC to a frequency.

Replace the jumper with a three-pin cable from the Turbo switch to make it possible to change the frequency of the system clock from the case switch.

Turbo LED

Connecting the turbo control LED can be very complicated if you include the digital speed display. We discussed this in Section 7.7.

NOTE

In this example, since we're interested only in the Turbo switch, we'll connect only the Turbo LED. We won't discuss the speed display.

The speed display's cable is a two-lead, black and yellow cable. The connector on the motherboard is almost always next to the contact for the Turbo switch, and is usually marked "LED".

After making all the relevant case connections for the motherboard, you must check them. Switch the PC back on and wait for the memory test to start. Then press the Reset button to clear the screen. The start routine automatically begins in approximately 10 seconds. If this doesn't work, the motherboard and the video card may be incompatible. Until you replace the video card, continue pressing Reset.

Turbo ticks faster

During the memory test you can test the Turbo switch. This changes the "counting rhythm," which you should be able to hear. In the fast setting, the yellow Turbo LED should light up; otherwise it's plugged in wrong. The green power LED should light up at the start and stay lit; the keyboard lock prevents keyboard input when you lock it. A locked keyboard results in an error message, such as "Keyboard locked", after the memory test.

If all the control lights and switches function correctly, you can switch off your PC. This step is finished.

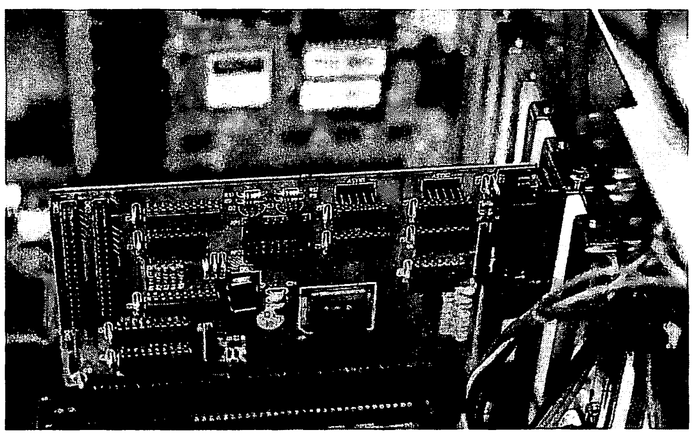
STEP 8:

Install AT Bus with ports

All enabled

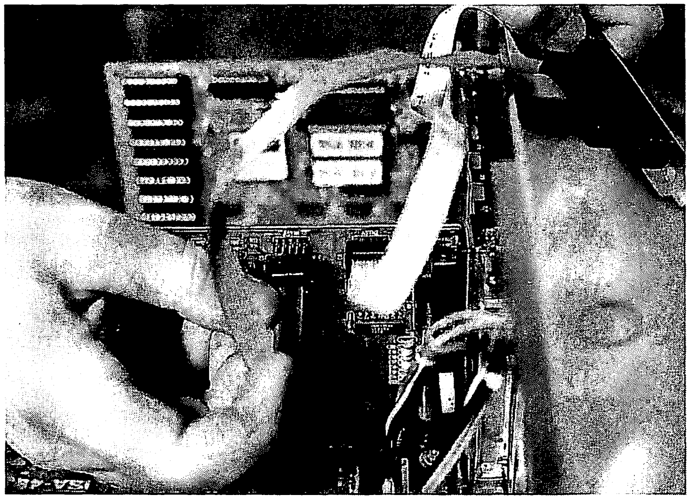
It's not difficult to install the combination controller. For this purpose, choose a 16-bit slot as close as possible to the drive mounting brackets so the cables will reach. The ports on the card are usually preset at the factory with all ports set to default addresses and all installed ports active. The IRQ layout of the serial ports also corresponds to the default settings (COM1=IRQ4, COM2=IRQ3).

Nevertheless, check these settings against the model you're using to ensure that they match. Correct the jumper settings if necessary. Often the diskette controller and the hard drive controller can be switched off separately. Check these settings as well. Both controller functions should be enabled.



Tighten the screws on the combination controller

Now insert the card in the slot and screw its faceplate to the case. Then plug in the two connector cables of the serial port faceplate to the appropriate contacts on the controller card. The connector labeled "ASYNC 1" is reserved for the first serial port. Use this port for the mouse cable.



Cable connections of the port faceplate

Then connect the other port to ASYNC2, the second serial port (COM2:).

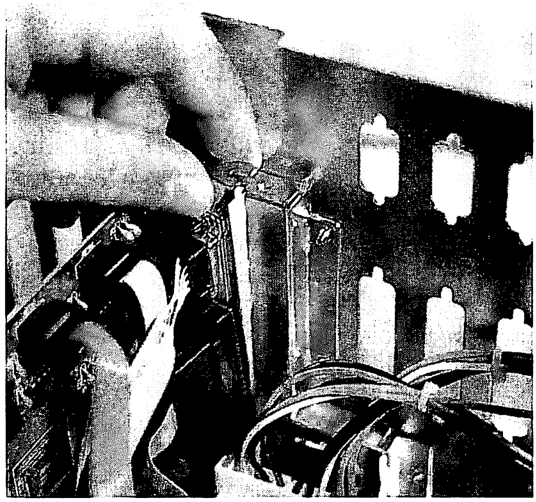
Connect the cables to the connector pins so the labeled side of the cable is connected to the connector pin marked "1". The last time you'll notice any errors is when you install Windows and the mouse won't work.

Now all you have to do is select which slot you're going to block by fastening the serial port faceplate. Unfortunately, there is no way to avoid doing this. Many cards are so big that you can't use the neighboring slot anyway.

NOTE

Another possibility would be to use an 8-bit socket, which is only useful for port or scanner cards anyway.

Now fasten the port faceplate to the back of the case with a screw.

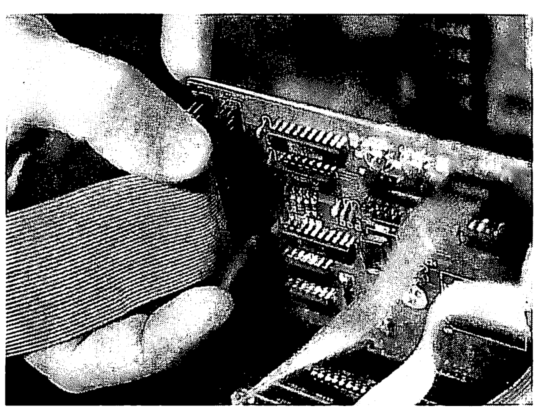


Installing the port faceplate

STEP 9:

Connect and test disk drive A:

Now let's install the first disk drive. For now, connect the disk drive. We'll install it later. Plug the long end of the 34-lead floppy cable into the post connector on the contact strip of the combination controller.

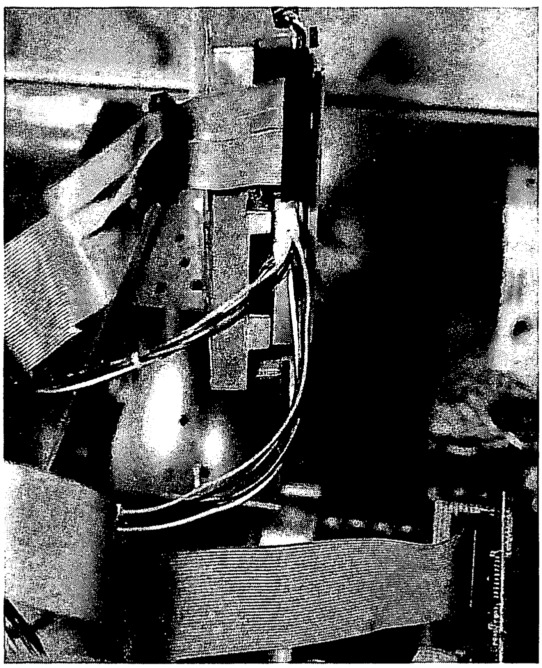


Connecting the floppy cable to the combination controller

The width of the cable indicates the location of the controller connection. The labeled side of the cable connects to connector pin "1" on the controller.

Place the disk drive (we assume it's a 5.25-inch disk drive with 1.2 Meg capacity) on its side on the power supply or the mounting unit with the control LED in view. Connect a power cable from the power supply unit to the appropriate connector on the disk drive.

Then plug the card connector on the twisted end of the floppy cable into the contact strap on the drive so the labeled side of the cable connects with the grooved side of the contact strap.



The disk drive is cabled

Entries in CMOS

Our next task is to enter the disk drive in CMOS SETUP. Switch on the PC and note the message that appears after the memory test. This message should read "Press [DEL] to run Setup" or something similar. Now press Del. Select the item "STANDARD CMOS" from the selection menu.

In the input window that appears, select "1.2 Meg" or "5.25-inch" for drive A:. Normally, you'll use the PgUp and PgDn keys to

scroll through the entries and make your selection. For now, leave the B: drive and the hard drive set to "NOT INSTALLED"; we'll discuss those settings later.

"Primary Display" or "Video" should already be set to "VGA/EGA". If there is a setting for "Keyboard", set it to "Installed". The memory size should already be entered correctly.

Press Esc to exit the input window and then choose "Write to CMOS and Exit". Answer the confirmation prompt that appears by entering "Y".

Testing your disk drive

When the computer reboots, it briefly accesses the disk drive following the memory test. It may display an error message as well. In any case, the computer then prompts you to insert a diskette with the operating system and press a key.

Insert the FAILSAFE diskette mentioned at the beginning of this chapter. Once the DOS system prompt appears, type the following

```
FORMAT A:
```

and press Enter.

The computer prompts you to remove the FAILSAFE diskette from the drive and insert a blank high-density diskette. Then press Enter to confirm the formatting procedure. If the diskette formats without any errors, you can concentrate on the second disk drive. Switch off the PC for now.

STEP 10:

Connect and test disk drive B:

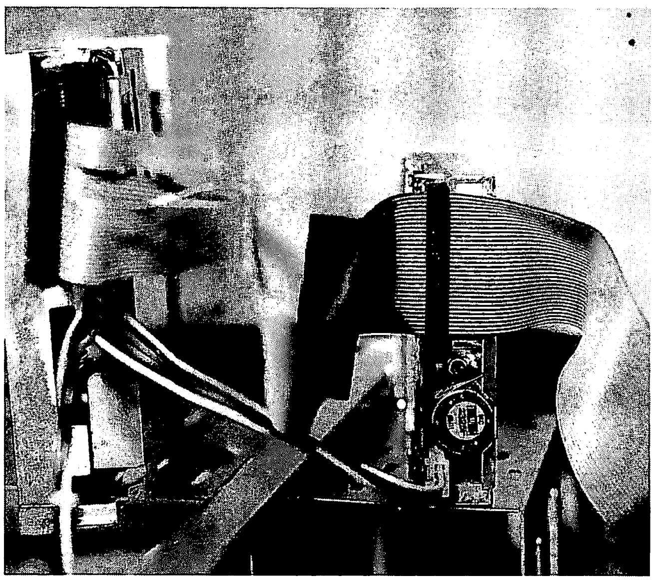
We'll also connect, set up, and test the second disk drive before physically installing both disk drives. Take the second disk drive and try to determine where "Pin 1" is located on the connector strip of the disk drive. Usually there is a matching label on the control board. Connect the drive's connector to the cable leading to the controller. Again, the side of the cable with writing on it matches "Pin 1".

Then attach the power connection of the disk drive to a power cable from the power supply unit.

CAUTION

Don't Use Force

It's possible to plug in these plugs incorrectly. Examine each one very carefully. Don't use force. Place this disk drive on its side on the power supply unit as well. Make certain you can see the control LED.



The second disk drive is also connected

When you switch on the PC again, first set up the disk drive in the STANDARD CMOS, as you did in Step 9. However, this time the entry is different; use either 3.5-inch or 1.44 Meg. After saving the entry and rebooting, the PC accesses both disk drives briefly and then tries to start from A:.

Insert the FAILSAFE diskette in drive A: and reboot. Repeat the formatting process in Step 9 for drive B:. If this disk drive also formats diskettes correctly, you're almost finished. Try changing to drive B:, read the directories of the diskette, switch back to drive A:, and display that diskette's directories as well.

If everything is correct, switch off the computer and unplug the power cable. You're finished with this step and are ready to physically install the disk drives.

STEP 11:

Install disk drives and tighten the screws

Caution: Cable length

Since both disk drives work well, you can install them.

First, determine which side of the 3.5-inch drive had the marked side of the cable. It's important to do this now because later it will be more difficult to distinguish the markings. Then disconnect all cables from the drives.

TIP

Frequently the larger tower cases have problems with the length of the cables. That's why it's better to leave the upper part of the tower free.

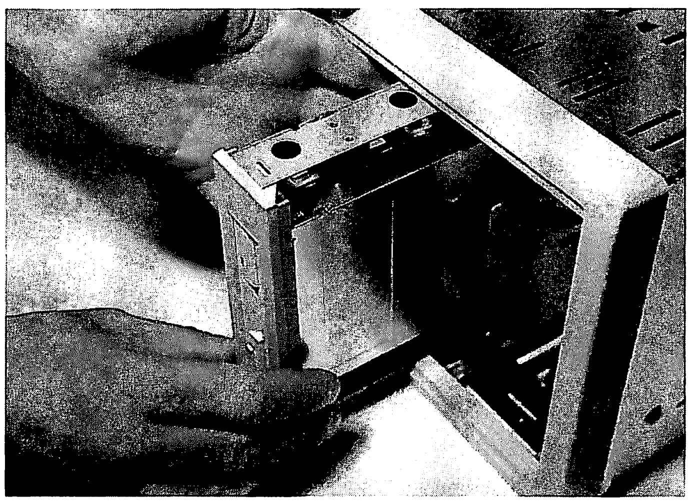
Install the A: drive in the second mounting bracket from the top and install the B: drive directly below it. To do this, you must temporarily place the tower in an upright position.

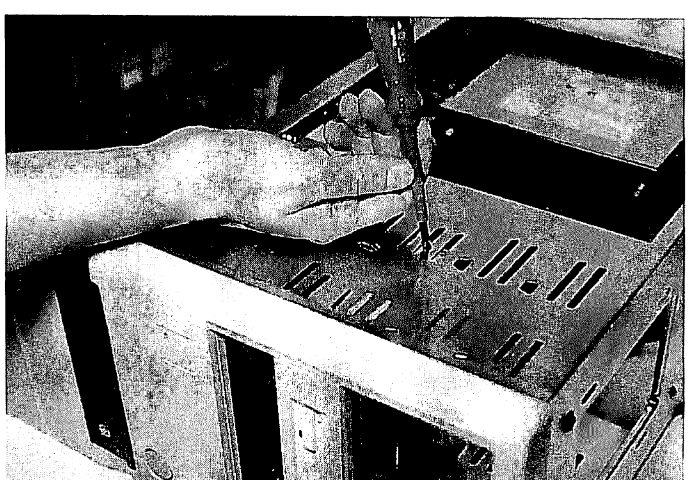
The 3.5-inch disk drive needs an installation kit

First the small disk drive

When you install the drives, always start with the 3.5-inch disk drive. Insert the drive into a 5.25-inch mounting kit and tighten the screws so the head arm points down. In our example the 3.5-inch drive is in position B: (the third mounting bracket from the top).

Now insert the drive with its frame in the case and tighten the four screws (two on each side). Be sure that you're using the right screws; they should screw in easily. If you're using a plastic mounting kit, you'll often use self-tapping (sheet metal) screws.





Slide them in and tighten the screws

With the head arm pointing down

Before you physically install drive A:, reconnect all the cables for drive B: while they're still easy to reach. Note the side of the cable that contains writing.

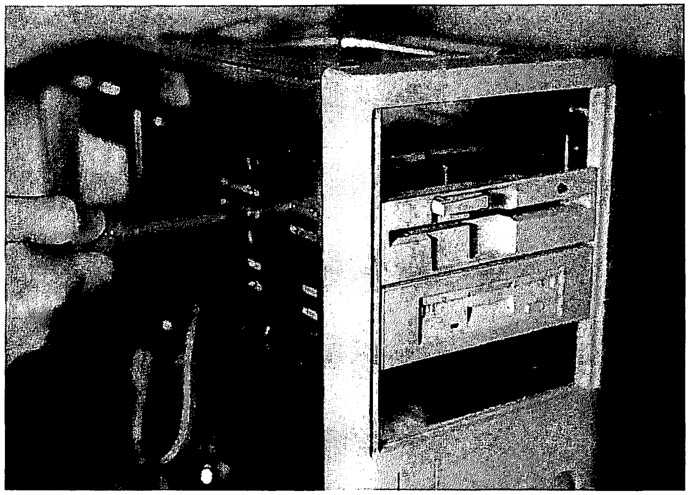
When all the cables are correctly installed, drive A: (5.25-inch) slides into the second unit from above, with the head arm pointing down. This drive also has two screws on either side.

Cable drive B: first

Now reconnect all the cables for this disk drive.

If all the cable connections are correct and the disk drives are installed, you can place the tower case on its side again. Switch on the PC for a minute to check your work.

Try accessing both disk drives and loading the operating system from the FAILSAFE diskette. Then switch off the PC and unplug the power supply. You're finished installing the disk drives.



Both floppies are mounted

STEP 12:

Connect and set up the hard drive

CAUTION

Don't Risk Your Hard Drive

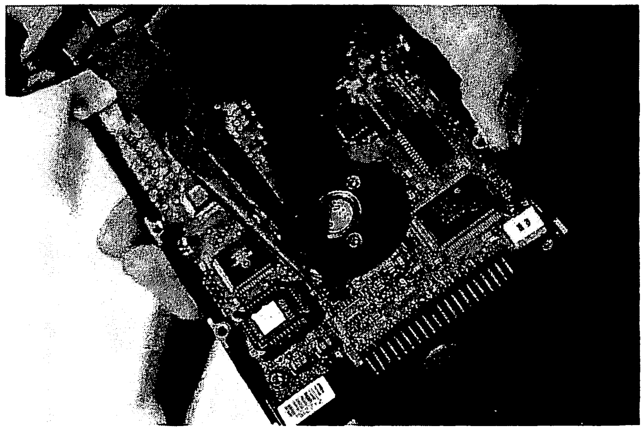
When the power to the PC is switched on, don't move, lift, or turn the hard drive. Even after switching off the power, wait one more minute before moving the hard drive.

The hard drive cannot slip, fall, or move while it's running. Although we suggest to "test first before installing", don't jeopardize your hard drive during testing. If necessary, install the hard drive first before testing.

AT bus hard drives are preset as the "Master"

AT bus hard drives are usually preset as "Master drive" in the setting "First and only hard drive". For the Conner CP 30104, this means that the middle jumper, "C/D", is enabled. While other

conditions apply for all other hard drives, as we have said, you usually won't have to check.

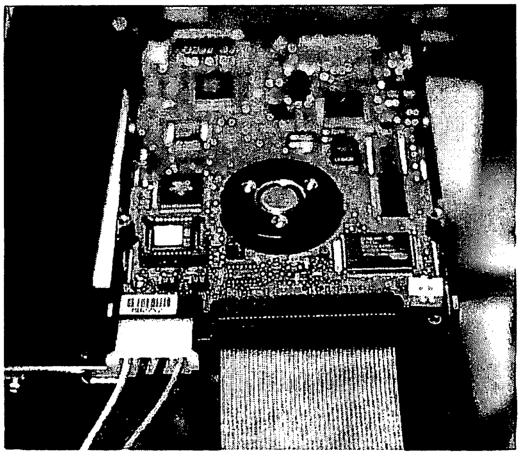


Checking the Master/Slave setting

Now connect one end of the 40-wire AT bus hard drive cable to the correct connector on the controller card. Ensure that Pin "1" goes on the labeled side of the cable.

Connect the other end to the connector block to the hard drive. Wire "1" on our Conner hard drive is on the inside, next to the power connection.

The connectors of most hard drives are organized in the same way. The hard drive also requires another power connection from the power supply unit. Now let's set up the hard drive on the system.



The hard drive is connected

C: drive error

Reconnect the PC to the power supply and switch it on. After the memory test, the PC soon displays an error message about discovering an unknown hard drive. The end of the message reads

```
C:Drive error
```

or

```
HDD controller failure
```

At the same time, the computer either prompts you to start CMOS SETUP or starts the program itself. Now enable the input window for STANDARD CMOS, then select type 47 (User Type) under "C:" or "Disk 1".

You can define this hard drive type yourself. Enter the parameters of the installed hard drive here. The only important values are the ones for cylinders, heads, and sectors. Use the following entries for our Conner CP 30104:

Item	Value
Cylinders	997
Heads	14
Write Precompensation	0
Landing Zone	0
Sectors	7

Write to CMOS and Exit

The second hard drive contains the entry "NOT INSTALLED". Save the entries and exit the input window again ("Write to CMOS and Exit"). The computer reboots but this time doesn't display an error message about recognizing the hard drive. However, you're still not finished with the hard drive. You have to prepare it for the operating system. We'll do this in the next step.

Check the boot sequence

The current 486 BIOS manufactured by AMI contains a setting option for the "System Boot Up Sequence" entry in ADVANCED CMOS SETUP. This is the sequence of drives used by the computer to search for the operating system.

The success of the next step depends on setting the "System Boot Up Sequence" to "A:;C:", meaning that the PC searches A: and then C: for the operating system. The "Floppy Drive Seek At Boot" entry should be "enabled".

To find these settings, go to ADVANCED CMOS SETUP after calling the CMOS SETUP program. Check these settings and make any necessary corrections. Press Esc to exit the menu and save the settings by selecting "Write CMOS and Exit".

For more information about ADVANCED CMOS SETUP, refer to Chapter 8.

STEP 13:

Partition and format the hard drive

After setting up your hard drive in CMOS SETUP, you must prepare it for working with MS-DOS. Insert your FAILSAFE

diskette in drive A: and press the Reset button. The system boots from the diskette.

A simple DOS prompt, showing the current drive as drive A:, appears:

```
A>
```

...and start FDISK

Next, call the partitioning program to set up the hard drive partition by typing:

FDISK [Enter]

```
                MS-DOS Version 6
             Fixed Disk Setup Program
     (C)Copyright Microsoft Corp. 1983 - 1993

                  FDISK Options

Current fixed disk drive: 1

Choose one of the following:
1. Create DOS partition or Logical DOS Drive
2. Set active partition
3. Delete partition or Logical DOS Drive
4. Display partition information
5. Change current fixed disk drive

Enter choice: [1]

Press Esc to exit FDISK
```

The FDISK main menu

In the main menu, select the first menu item, "Create DOS partition or Logical DOS Drive". Since the value "1" is already preset in the line "Enter choice:", confirm by pressing [Enter].

```
Create DOS Partition or Logical DOS Drive

Current fixed disk drive: 1

Choose one of the following:

1. Create Primary DOS Partition
2. Create Extended DOS Partition
3. Create Logical DOS Drive(s) in the Extended DOS Partition


Enter choice: [1]


Press Esc to return to FDISK Options
```

The second step

In the "Create DOS partition or Logical DOS Drive" submenu that follows, select the "Create Primary DOS Partition" (default) option again.

Then press Enter. The following question appears:

```
Do you wish to use the maximum available size for a
Primary DOS Partition and make the partition active
(Y/N).....? [Y]
```

Choose the default "Y" and press Enter.

Now watch the computer access the hard drive as it creates your partition. Then the computer displays the following message on the screen:

```
Now rebooting the system. Insert an MS-DOS system
diskette in drive A:. Press any key when ready...
```

Since you already have your FAILSAFE diskette in the drive, press Enter.

The system performs a warm boot and is loaded again from the diskette.

Now you're ready to format your hard drive. To do this, type

...and format

```
FORMAT C:/S
```

and press Enter.

Answer the security prompt

```
WARNING! ALL DATA ON NON-REMOVABLE DISK
DRIVE C: WILL BE LOST!
Proceed with Format (Y/N)?
```

by pressing Y and then Enter.

The computer formats the hard drive. Notice the hard drive LED blinking and a ticking noise. The format routine keeps you updated on the progress of the formatting:

```
34, 35, 36 percent completed
```

Then you see the messages

```
Format complete
```

and

```
System files transferred
```

Answer the prompt

```
Volume label (11 characters, ENTER for none)?
```

by pressing Enter. Then you'll see an overview of the available disk space on your newly installed hard drive.

```
A:\>format c: /s

WARNING, ALL DATA ON NON-REMOVABLE DISK
DRIVE C: WILL BE LOST!
Proceed with Format (Y/N)?y


Formatting 112.32 MB
Format complete.
System transferred

Volume label (11 characters, ENTER for none)?

 117534720 bytes total disk space
    124928 bytes used by system
 117409792 bytes available on disk

      2048 bytes in each allocation unit.
     57329 allocation units available on disk.

Volume Serial Number is 2629-16F6
Format another (Y/N)?n
C:\>
```

Formatting complete

Since the hard drive is completely formatted, you can now copy the operating system, programs, or other data to the drive. Remove the diskette from drive A: and press Reset to see whether the hard drive also boots.

After the new operating system prompts you for the date and time (press Enter to bypass the prompts), it displays the following lines:

```
Microsoft (R) MS-DOS (R) Version 5.00 (C) Copyright
              Microsoft Corp. 1981-1991
```

Switch off the computer and physically install the hard drive.

STEP 14:

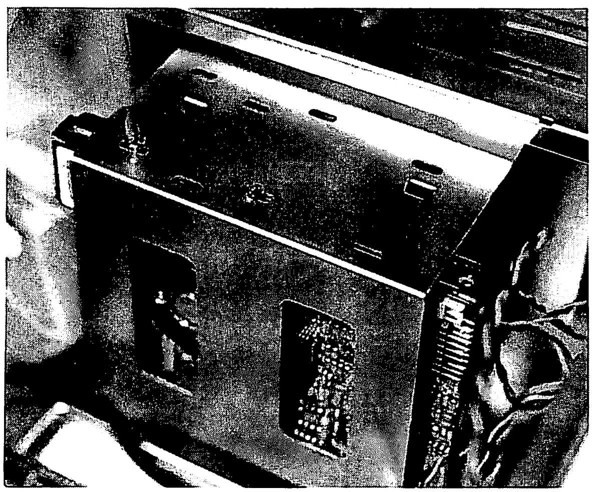
Install the hard drive and tighten the screws

First, disconnect all cable connections to the hard drive. All modern tower cases have a kind of metal box for installing a 3.5-inch hard drive. Usually this box is under the disk drive mounting

brackets. This box is specially designed for installing 3.5-inch hard drives.

CAUTION

Be careful when fastening the screws. If they're too long, they could bore through the control board of the hard drive (especially Conner hard drives). To be safe, test the screws first. Make certain that the electronic circuitry of the hard drive doesn't touch other components. Then reconnect all the cables.

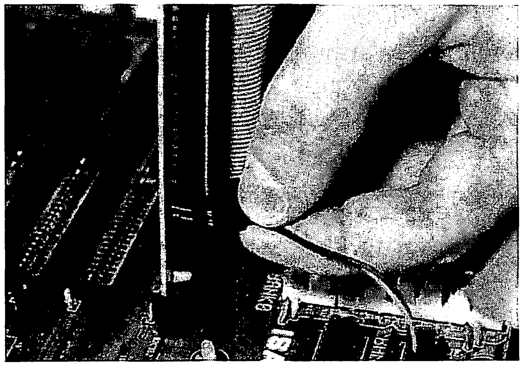


Installing the hard drive

Hard drive control

You should also connect the cable between the hard drive control LED on the front of the case and the hard drive controller. Usually this is a red and black or red and white two-wire cable.

The combination controller has either a two-pin or four-pin connector. The red wire of the cable goes on Pin "1" of the connector. Test the connection by checking the control LED. The control LED indicates hard drive activity.



The hard drive control LED is connected to the controller

After you finish physically installing the hard drive, you can begin installing the operating system.

STEP 15:

Install MS-DOS on the hard drive

NOTE

To install MS-DOS 5.0, you need all the original MS-DOS 5.0 diskettes.

Insert diskette 1 into drive A: and run A:SETUP. It boots from the diskette and displays the MS-DOS SETUP screen. Press Enter to go to the next menu.

Settings

To change settings, select the menu item and press Enter.

DOS Shell is not active

In the menu that now appears on the screen, select the "MS-DOS Shell:" option and press Enter. From this submenu, select "Do not run MS-DOS Shell on startup." and press Enter. We're selecting this option because later we'll install MS-Windows.

If all settings are correct, select "Continue Setup: The information above is correct." and press Enter. Follow the instructions on your screen.

Inserting diskettes

During installation, MS-DOS prompts you to insert different diskettes into the appropriate drive. After you've inserted all the diskettes, the computer displays a message that installation is complete. Remove the diskette from the drive and reboot your computer.

After rebooting, type the following command

```
DIR
```

to ensure that the DOS Setup program created a directory called

```
C:\DOS
```

on your hard drive.

This concludes the installation of DOS. Now you can begin configuring the operating system.

STEP 16:

Make manual changes to start and configuration files

The editor

We'll begin the system configuration adapting configuration files with the CONFIG.SYS file. We'll use the editor included with DOS. To call the Editor, type the following line:

```
EDIT CONFIG.SYS
```

The editor screen should appear. Look for a line that reads:

```
DEVICE=C:\DOS\SETVER.EXE
```

Move the cursor to this line, and press Ctrl and Y simultaneously.

Manually changing the CONFIG.SYS

The following line should be the first line of CONFIG.SYS:

```
DEVICE=C:\DOS\HIMEM.SYS
```

Use the arrow keys to move the cursor down one line so it's at the beginning of the second line and press Enter. A blank line appears above the cursor. Move the cursor to this blank line and type the following text:

```
DEVICE=C:\DOS\EMM386.EXE NOEMS
```

Then go down one line and add ", UMB" to the line

```
DOS=HIGH
```

so the third line of your configuration file now reads:

```
DOS=HIGH, UMB
```

Now add another blank line as previously described and type:

```
DEVICEHIGH=C:\DOS\SMARTDRV.SYS
```

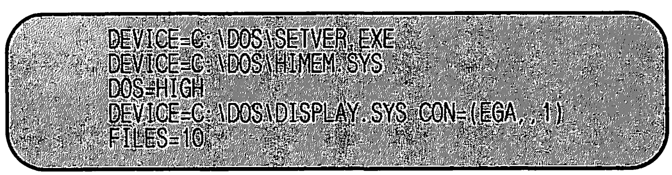
Change the number 10 in the FILES line to 30, so it reads:

```
FILES=30
```

Your new CONFIG.SYS file is now ready.

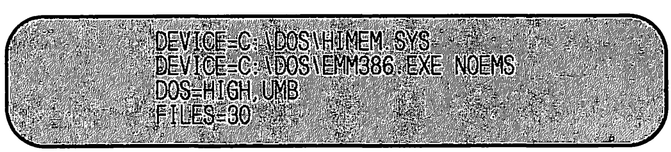
Now press Alt and F to activate the **File** menu and select **Exit**. Press Enter and answer the question about saving the loaded file by pressing Enter again.

Your new CONFIG.SYS file is now in the root directory of your hard drive.



```
DEVICE=C:\DOS\SETVER.EXE
DEVICE=C:\DOS\HIMEM.SYS
DOS=HIGH
DEVICE=C:\DOS\DISPLAY.SYS CON=(EGA,,1)
FILES=10
```

The "old" CONFIG.SYS



```
DEVICE=C:\DOS\HIMEM.SYS
DEVICE=C:\DOS\EMM386.EXE NOEMS
DOS=HIGH,UMB
FILES=30
```

The "new" CONFIG.SYS

You can update the AUTOEXEC.BAT file in a similar way. Load it in the DOS Editor by typing:

```
EDIT AUTOEXEC.BAT
```

DOS 5.0 and the AUTOEXECBAT

When the file appears on the screen, first delete all lines beginning with

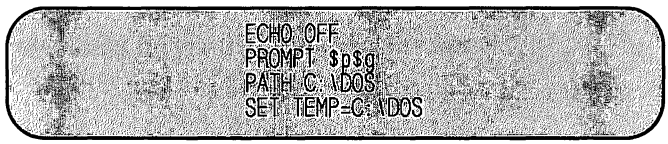
```
MODE CON CODEPAGE
```

by moving the cursor to each line and pressing Ctrl Y.

Add the following as the last line of AUTOEXEC.BAT:

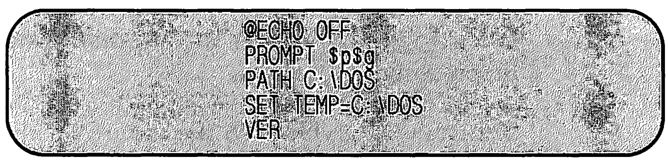
```
VER
```

Exit the program as previously described for the CONFIG.SYS file.



```
ECHO OFF
PROMPT $p$g
PATH C:\DOS
SET TEMP=C:\DOS
```

The "old" AUTOEXEC.BAT



```
@ECHO OFF
PROMPT $p$g
PATH C:\DOS
SET TEMP=C:\DOS
VER
```

The "new" AUTOEXEC.BAT

Ensure that your changes are correct by typing

```
TYPE CONFIG.SYS
```

and

```
TYPE AUTOEXEC.BAT
```

Then reboot your computer.

Almost 630K free memory

After booting up, type

```
MEM
```

to find out that your DOS applications have 627728 bytes available, although you installed a hard drive cache.

```
C:\>mem

655360 bytes total conventional memory
655360 bytes available to MS-DOS
627728 largest executable program size

3145728 bytes total contiguous extended memory
0 bytes available contiguous extended memory
2894848 bytes available XMS memory
MS-DOS resident in High Memory Area

C:\>
```

Free memory under DOS 5.0

However, when you install Microsoft Windows 3.1, this configuration will change again.

STEP 17:

Install Windows 3.1 on the hard drive

NOTE

You'll need the original Windows 3.1 diskettes for this step.

Start the installation by inserting the diskette labeled "Diskette 1 - Setup" into drive B: (for 3.5-inch diskettes). Change to the drive by typing:

B: Enter

Call the installation program by typing:

SETUP

Two paths, one goal

After a short wait, you'll see the welcome screen of the Windows Setup program. Press Enter to exit this screen and go to the next menu where you can choose either a user defined installation or a standardized installation of Windows.

Press E to select Express Setup, which is faster and easier.

Next, Windows Setup checks the configuration of your hardware and begins transferring Windows files. Occasionally, the program prompts you to insert another diskette into drive B:. After you insert the diskettes, remember to press [Enter] again. The screen eventually changes to Windows.

Does the mouse work?

If you installed the mouse port properly, you can now use your mouse for the first time. Move the mouse back and forth to see whether the mouse pointer (the little white arrow on the screen) also moves.

Enter your name

Now you must type in your name. You need your keyboard in order to do this. Type your name in the appropriate box; you can also include your company's name or anything else that seems important.

Move the mouse pointer to the appropriate box and click the left mouse button. When you're finished typing in the name, click the [Continue] button to exit this menu. Windows then asks you whether the name is correct. Confirm by clicking [Continue] again.

Printer installation

When the dialog box for printer setup appears, don't select any printer for now.

After one or two more diskettes, Windows begins building its program structure. You can follow this process on the screen. Then Windows searches your hard drive for applications that are already installed. It will find two programs, DOS-EDIT and QBasic. Since we don't want to run these programs under Windows, click the [Cancel] button.

Since we also think it would be better to skip running the tutorial after Windows is completely installed, click the [Do not run tutorial] button.

Then, you go to the last step of Windows Setup. Select the button that completely reboots the system.

Even more memory!

After the computer finishes booting, type the following:

MEM [Enter]

You'll probably be surprised to discover that the amount of your computer's free memory has increased again, even after installing Windows. Now you have 632352 bytes.

```
C:\>mem

655360 bytes total conventional memory
655360 bytes available to MS-DOS
632352 largest executable program size

3145728 bytes total contiguous extended memory
      0 bytes available contiguous extended memory
1826816 bytes available XMS memory
        MS-DOS resident in High Memory Area

C:\>
```

Modified memory map after installing Windows

You now have more memory because of the improved HIMEM and SMARTDRV drivers used by Windows. Setup made the necessary changes in CONFIG.SYS and AUTOEXEC.BAT automatically. Check WINDOW's work by typing:

`TYPE CONFIG.SYS` Enter

and

`TYPE AUTOEXEC.BAT` Enter

Then type

`DEL *.OLD` Enter

to delete the backup copies of the old configuration files.

```
C:\>type autoexec.bat
C:\WINDOWS\SMARTDRV.EXE
@ECHO OFF
PROMPT $p$g
PATH C:\WINDOWS;DOS
SET TEMP=C:\DOS
VER


C:\>type config.sys
DEVICE=C:\WINDOWS\HIMEM>SYS
DEVICE=C:\WINDOWS\EMM386.EXE NOEMS
DOS=HIGH,UBM
FILES=30
STACKS=9,256
```

The modified startup files

Now you can start your new program, Windows, for the first time. Type the following at the DOS prompt:

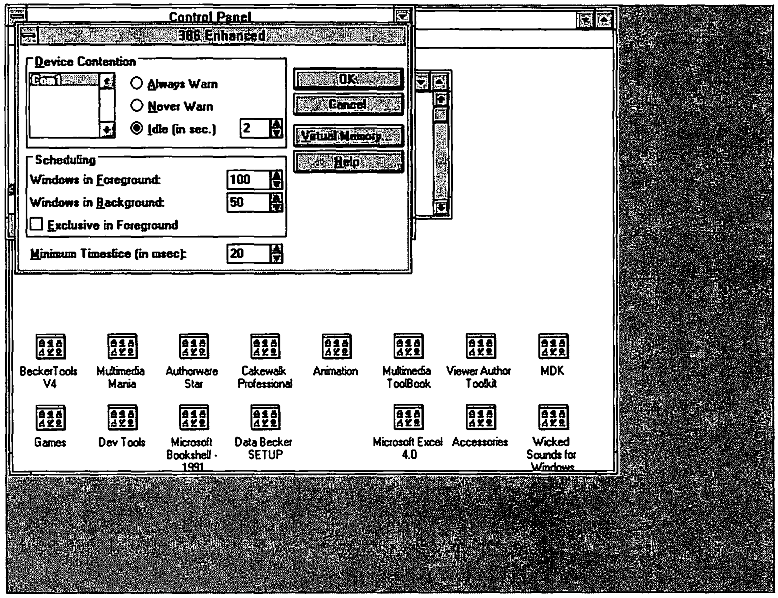
`WIN` Enter

Windowing for the first time

The Windows 3.1 logo is followed by an open window called the Main group. Notice the name "Main" in the title bar at the top of the window. This group combines the main functions of Windows. Before doing anything else in Windows, let's set up a permanent swap file.

Setting up a permanent swap file

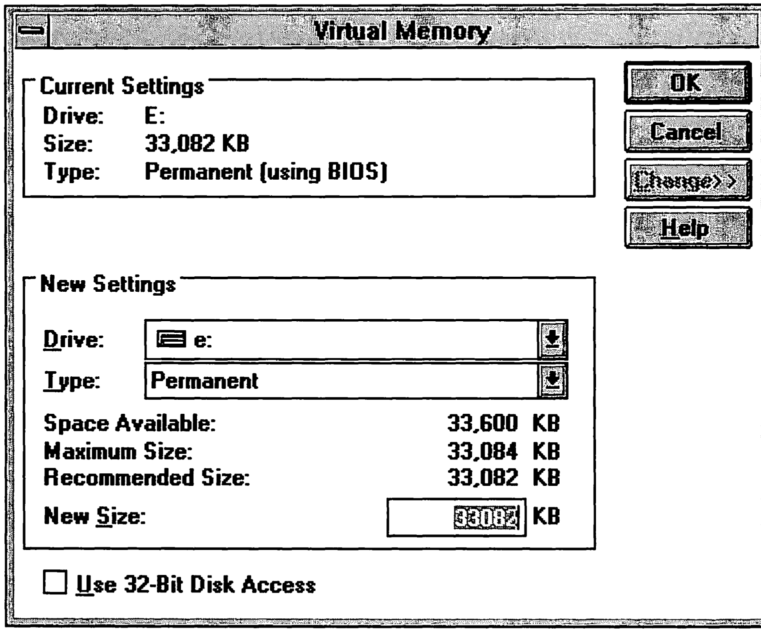
Double-click the "Control Panel" icon. This takes you to a new window with an icon called "386 Enhanced". Double-click this icon and click on the [Virtual Memory...] button in the 386 Enhanced submenu. You go to another submenu where you'll find information about the Windows swap file.



386 Enhanced

Now click on the [Change] button (on the right) and watch the window increase in size. This new area at the bottom contains some options related to the size and type of the Windows swap file. Windows also has a default setting for each option.

Accept Windows' setting by clicking the [OK] button. Don't worry about the size of the file (you can change it any time you wish) or the confirmation message that follows ("Are you sure you want to ...?"). Then click on the [Restart] button to affect the changes.



Accept Windows' settings

STEP 18:

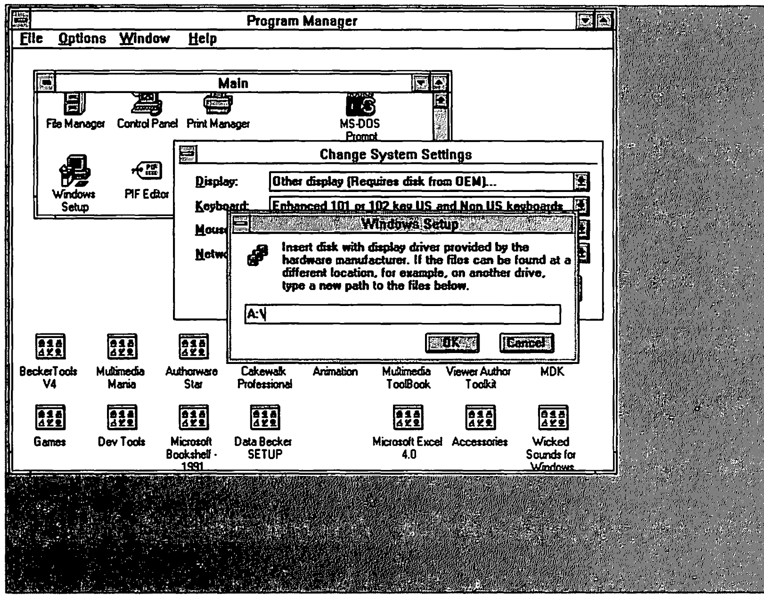
Install the driver software of the video card

Keep your diskettes ready

To do this, double-click the "Windows Setup" icon in the "Main" group. A window opens on the screen with information about your current configuration. Select the **Options** menu, and then click on **Change System Settings...**.

In the next window, you'll find your video card type (probably **VGA**) listed in the **Display:** line. To the right of this entry you'll see a small arrow pointing down. Click on this arrow to activate the drop-down list box for **Display:**.

Now move the cursor down to the last position, called "Other display (Requires disk from OEM)...".



You'll need a driver diskette

As soon as this option is selected (highlighted), press Enter and insert the Windows driver diskette into drive A:. After Windows finishes reading the diskette, you'll see a small menu with various graphics resolutions. Select **640*480 in 256 Colors** and click on OK.

After loading the driver, you must still insert a Windows original diskette. Change to the appropriate drive, click on OK and follow the instructions on the screen.

Then restart Windows to make the video driver active.

STEP 19:

Prepare the sound card

You can accept the default settings

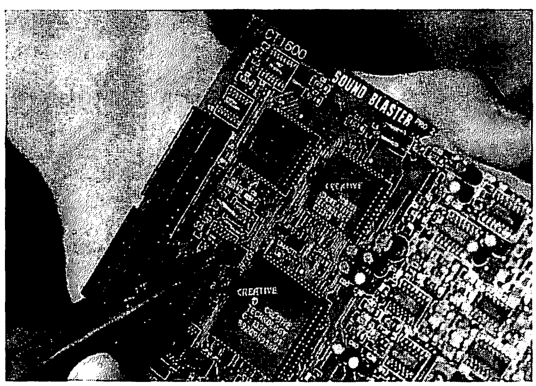
Installing Microsoft Windows 3.1 meets the basic requirements for hardware and software installation of a sound card and a CD-ROM drive. Before physically installing the Sound Blaster Pro card, check the default settings and make any necessary modifications.

The default setting "IRQ 7" usually won't cause problems, as long as you don't make both the sound card and the printer active simultaneously.

The jumper on the card labeled "JP19" is on when IRQ 7 is used. If another IRQ is changed, the various application and demo programs must be informed of this during installation. In other words, leave this setting unchanged. This also applies to the port address set to 220 Hex through JP13.

Two game ports aren't needed

Since two different joystick ports aren't necessarily compatible on one PC and the combination controller card already has one active game port, you must disable the joystick port on the sound card. Use the jumper called "J4" on the Sound Blaster Pro card to disable the port. Simply remove the jumper on J4 to set the integrated game port to "disabled."



Disabling the game port

STEP 20:

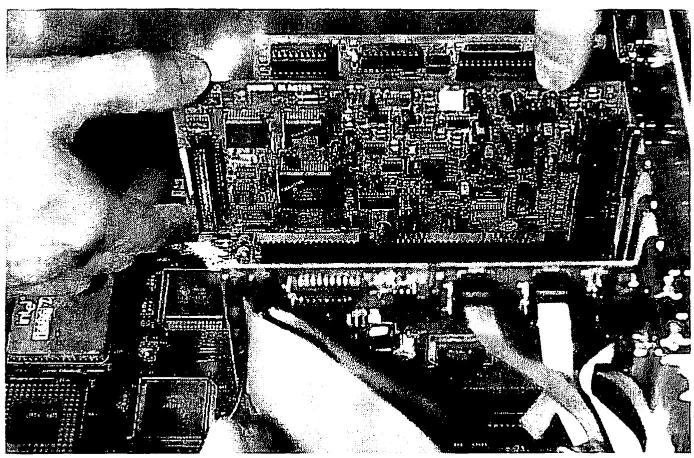
Install the sound card

It's easy to install the Sound Blaster Pro card or any other card. Although it's an 8-bit card, you can insert it into any 16-bit slot.

TIP

Remember, the card shouldn't be too close to any other expansion cards. The card contains several components that are sensitive to heat. To prevent heat buildup, leave one slot free between the sound card and the other cards.

It's also important to remember that the Sound Blaster Pro card contains the controller for the CD-ROM you plan to install. So don't install the sound card too far from the CD drive (use the cable length as a guide). There is also an audio cable between the CD-ROM and the sound card to consider. Choose the right slot and fasten the card to the back of the case with a screw.

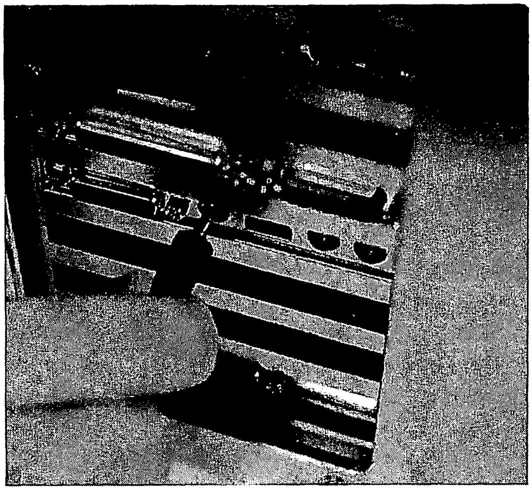


Inserting the sound card

STEP 21:

Hook up the external speakers

Connect a boom box, stereo system, or amplified speakers, to fully use the Sound Blaster Pro card's capabilities. To do this, connect the supplied cable for connection to the stereo and the sound card output. Set the volume control of the sound card to a medium level.



Connecting the speakers to the sound card

STEP 22:

Install the software for the sound card

Use the sound card's original installation diskette. Insert the diskette into drive A: and begin installation by typing:

```
A: Enter
INST_HD C: Enter
```

The automatic installation routine starts and prompts you to specify the settings made on the card.

Continue using the default values (IRQ7, DMA1 and port address 220).

The \SBPRO directory

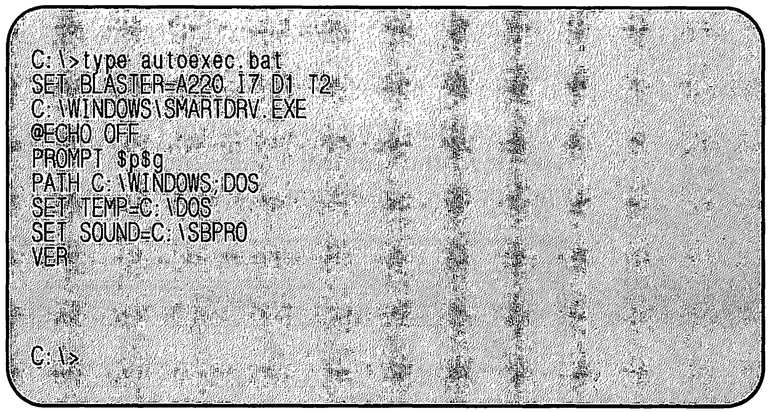
Next, the installation routine creates a directory called SBPRO and copies the various supplied programs into separate subdirectories of this directory.

The SBPRO directory also contains some batch files that you can run to call the programs for you.

Environment variables

Then the installation program adds the following to your AUTOEXEC.BAT file to configure the Sound Blaster Pro card through the BLASTER and SOUND environment variables:

```
SET BLASTER=A220 I7 D1 T2
SET SOUND=C:\SBPRO
```



The expanded AUTOEXEC.BAT

This concludes the installation of the Sound Blaster Pro software. Now let's find out if the card works.

STEP 23:

Test the sound card

To test the sound card, reboot the system by pressing Ctrl + Alt + Del to make the changes in the system settings active.

Then type the following

```
CD SBPRO
```

to change to the SBPRO directory and type DIR to view the number of programs. Experiment with some of the programs and learn about the options and limitations of your Multimedia PC. Then, we'll move on to the next step.

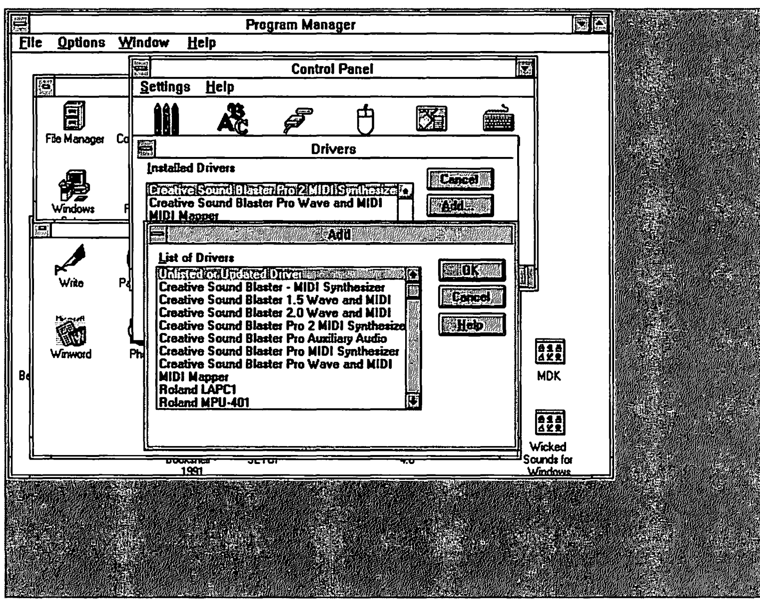
STEP 24:

Link the sound card to Windows 3.1

To begin actual Multimedia installation, first load Windows, by typing:

```
WIN
```

Then call the Windows "Control Panel" in the "Main" group. Once you're in the Control Panel, click on the "Drivers" option. Then click on the [Add] button and select "Unlisted or Updated Driver".



Selecting a MIDI title

Then, a dialog box appears, prompting you to insert a diskette with the OEMSETUP.INF file or specify the path for this file. Enter the following in this box:

```
C:\SBPRO\WIN31
```

Now you'll see a list of the available drivers. Install each of these drivers and specify the default values for IRQ, DMA, and the port address.

After each driver, Windows prompts you to restart the computer to make the driver active. Select "No Restart" until you have installed the last driver. Then select "Restart Windows". Then you return to the Program Manager.

The sound card gets its own group

Now select **File/New/Program Group** to add a new group file to the Program Manager. Name the group file BLASTER and then copy the MMCBOX.EXE, MMJBOX.EXE, and SBPMIXER.EXE programs to this file. These program files are in subdirectories of C:\SBPRO.

Run the "Drivers" icon again to install sound drivers, and "MIDI Mapper" to select a MIDI driver to match your sound card (this may require setting MIDI ports to match the sound card, rather than the default MIDI Out). For more information on MIDI Mapper, see ***The Sound Blaster Book***, from Abacus.

Then select "Media Player" from the "Accessories" group. Choose a piece of music by selecting **File/Open...**. You can play back any file with the .MID extension (e.g., CANYON.MID). To play the file, click on the PLAY icon of the Media Player. It resembles a play button on a cassette recorder.

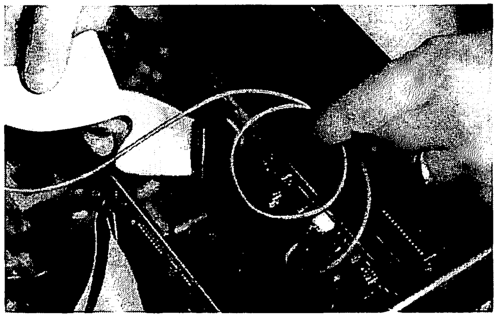
STEP 25:

Connect the CD-ROM drive

CD-ROM drive

Your multimedia PC still needs a CD-ROM drive. Connect this mass storage system and do a test run before you screw it into the case. First connect one end of the flat ribbon cable for data transfer to the connector block of the controller, which is on the Sound Blaster Pro card in our example. The other end of the cable is a 40-wire AT bus cable on our Matsushita drive. Connect it to the post strip on the drive.

When you connect this cable, the marked side of the cable goes with Pin "1" of the connector. If you find a free outlet on the power supply, use it for the CD-ROM drive. Otherwise, you must use a Y power splitter. For now, position the CD-ROM drive on the tower case.



The CD-ROM drive is connected to the sound card twice

Don't forget the audio cable

Finally, connect the audio cable to the CD-ROM drive and the sound card so you can play audio CDs from the Sound Blaster Pro in addition to data CDs.

The Sound Blaster Pro has a special software program for this purpose. The sound card and CD-ROM drive that we chose won't cause any problems with incompatible plugs or plug layout.

STEP 26:

Set up the CD-ROM drive under DOS

Installing the software for your CD-ROM is similar to installing the Sound Blaster software. First, insert your original installation diskette into drive A: and type

```
A: [Enter]
INST_CD C: [Enter]
```

to begin installation. Confirm the default settings for IRQ, DMA, and the port address, and follow the other instructions.

The installation routine now installs the software for the CD-ROM in the C:\SBPRO\DRV directory and adds the following line to the CONFIG.SYS:

```
DEVICE=C:\SBPRO\DRV\SBPCD.SYS /D:\MSCD001 /P:220
```

However, you have to add the following line to your CONFIG.SYS file:

```
DEVICE=C:\DOS\SETVER.EXE
```

Run the DOS Editor as follows:

```
EDIT CONFIG.SYS
```

Add the above device line, following the EMM386 driver.

To assign a drive letter to your CD-ROM, call the following batch file from the C:\SBPRO\DRV directory:

```
CDDRIVE
```

This executes the MSCDEX program with a few parameters. To be able to address the CD-ROM drive at all times, type:

```
EDIT AUTOEXEC.BAT
```

Add the following to your AUTOEXEC.BAT file:

```
CALL C:\SBPRO\DRV\CDDRIVE.BAT
```

Then insert your CD and reboot the system. When the computer finishes booting, type

```
D:
```

to change to your CD-ROM drive, as if it were a normal hard drive.

STEP 27:

Test the CD-ROM drive

Special error 65

Type

```
DIR
```

to take a look at your new drive. Copy some files to your hard drive or run a program on the CD-ROM drive. Don't be afraid to experiment. By experimenting, you test the drive and become more familiar with the new technology.

Try deleting a file on the CD-ROM. Although the CD-ROM drive behaves like a completely normal hard drive for the Windows File Manager too, you cannot write to the drive.

After you load Windows, you'll have a drive D: available. Use the multimedia software to test the CD-ROM drive. Also, run any programs or demos your CD might have on it. As soon as you think everything is working properly, finish putting your computer together.

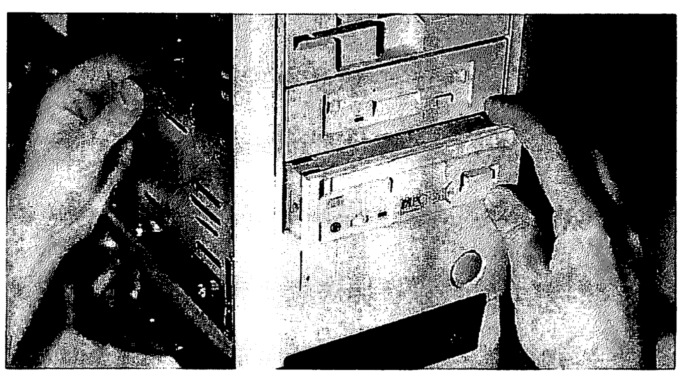
STEP 28:

Install the CD-ROM drive and tighten the screws

Now that you've adapted your CD-ROM drive for use under DOS and Windows, you're ready to physically install it.

Disconnect all the cables from the drive. Disconnect all the cables from the PC and the power supply too, since you're finally ready to move the case to an upright position. The CD-ROM drive is the last device to be installed.

It's time to close the case. Place the CD-ROM drive underneath the two disk drives in the closest free bracket and fasten it to the case as you did with the two disk drives, with two screws on either side. Then reconnect all the cables (data cable, audio cable, power cable). This concludes the installation of the CD-ROM drive.



Installing the CD-ROM drive

STEP 29:

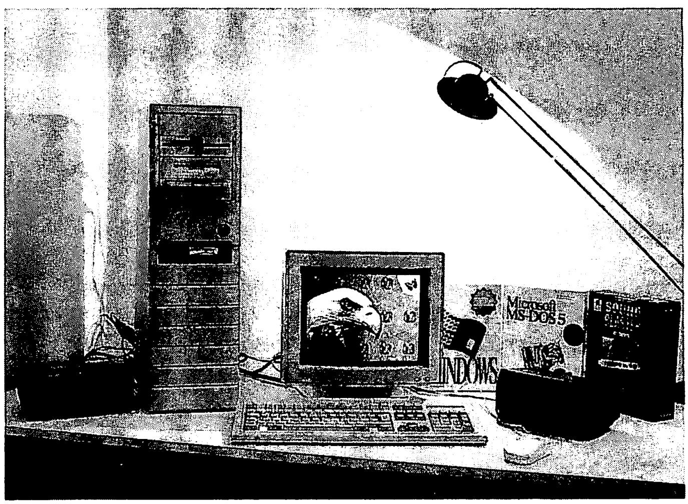
Close the case

Finally finished!

Does everything function correctly? If so, there's no reason to leave the case open. If some screws haven't been used, try to find the ones for the tower case (there are probably six of them).

Disconnect all the cables so you can put the top of the case back on. Some tops have small guide rails at the bottom that fit into grooves on the bottom of the case. Then tighten all six screws to the case.

Congratulations, you did it. Your multimedia 486 is ready for use. Have fun with it.



The finished multimedia PC

9.2 Final Suggestions and Helpful Tips

Speakers

Active and passive

A sound card, like a stereo system, is only as good as its speaker system. They can be either active or passive. Active speakers have their own built-in amplifiers and volume controls. These speakers boost the sound received from the sound card output.

Power supply

Active speakers require batteries or a separate power supply. We recommend using a power supply, since batteries can wear out quickly.

Passive speakers play the sound card output without further modification. Volume is controlled at the card itself. With a sound card capable of 4 watts at 4 ohms per stereo channel, ordinary passive speakers, like those used on most stereo systems, are suitable.

Make certain to look for shielded speakers. Speakers contain magnets which are strong enough to distort the picture on the monitor. Since you're likely to place at least one speaker near the monitor, the distortion could be quite noticeable. Shielded speakers on the other hand have no affect on your monitor because they shield the magnetic field.

Car speakers also work well, since they are compact and produce high-quality sound.

You could also use speakers designed for use with a Walkman-type personal stereo/cassette player. They're enclosed in finished cases and are affordable. However, they seldom produce the desired quality from a 16-bit sound card that you'll need in your multimedia presentations. We recommend using these speakers only in preliminary work or if you have no other choice.

You could also use your stereo by connecting the auxiliary input jack on your stereo. Since stereo speakers are designed for quality output, the quality of control of the sound is quite good. However, this requires that your computer system and stereo equipment be close together. You also lose the portability of external speakers.

Microphones

A sound card meeting MPC specifications must have a microphone connector. This enables you to record voice or sound effects. By using a sound editor such as those from Voyetra Technologies, Turtle Beach Systems, Inc., and others, you can create, edit and play your own sound files.

A good microphone should have the following features:

Microphone Features	
Feature	**Ideal setting**
Impedance	600 ohms
Sensitivity	74 decibels (dB) or higher

If excellent recording quality isn't a major factor, the built-in microphone of a portable stereo recorder should be sufficient.

Joysticks

Several games already use sound cards to create extremely realistic sound effects. In many of these games, the player moves a joystick to guide the cursor on the screen, then triggers a certain action at the desired position by pushing the fire button. Most sound cards have a joystick connector.

You probably need to calibrate an analog joystick before you can use them in a game. Refer to the documentation for your applications for more information on joystick calibration.

Sound card requirements

Sound cards generate, record or play back sounds of any kind. These sounds include speech, music and sound effects. Besides recording over a microphone or stereo system connected to your sound card, you can create and record your own musical compositions on special synthesizers or keyboards attached through a MIDI interface.

Connection options

Microphone and Line-in connector

In addition to a sound card's general performance capabilities, the connections it offers to external audio sources is also important. You should be able to connect your sound card to a microphone and to a stereo system.

With these capabilities, you can make music, radio and voice recordings, and even mix microphone input with other audio signals.

As an alternative to direct microphone input, you can connect your sound card to another device (e.g., a tape player) through the

Line-in connector. This allows you to record sounds at remote locations and then transfer them to your computer.

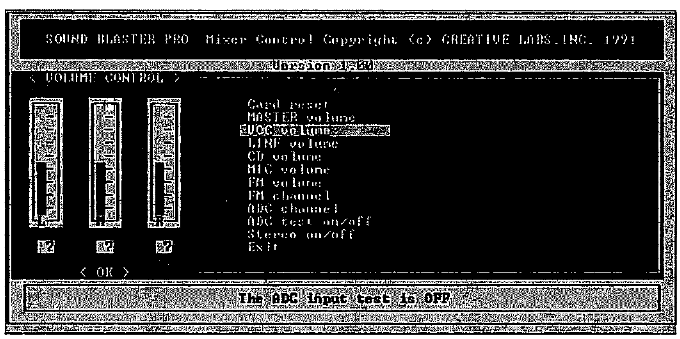
Speaker connection

Obviously, another important connection is for speakers. As we mentioned, you can use active or passive speakers, depending on your needs and your sound card's output capacity.

Software volume control

Volume is usually controlled by appropriate software. Most sound cards include a mixer program. Additional features you should look for in sound cards include the following:

- Mixer program to regulate output volume.
- Mixer program which enables separate volume control for each input and output signal.
- Balance control (independent settings for the left and right stereo channels).
- Volume control on the back of the card.



Volume control for the Sound Blaster Pro

MIDI

Another important connection, which is also part of the MPC standard, is a MIDI interface. MIDI (Music Instrument Digital Interface) is a standardized (manufacturer-independent) file format for recording and exchanging musical instrument sound data.

Besides the actual musical notes, a MIDI file contains information such as dynamics, articulations, and instrument types. When

played, the music is created by a sound card's synthesizer chips or by a synthesizer connected through a MIDI interface.

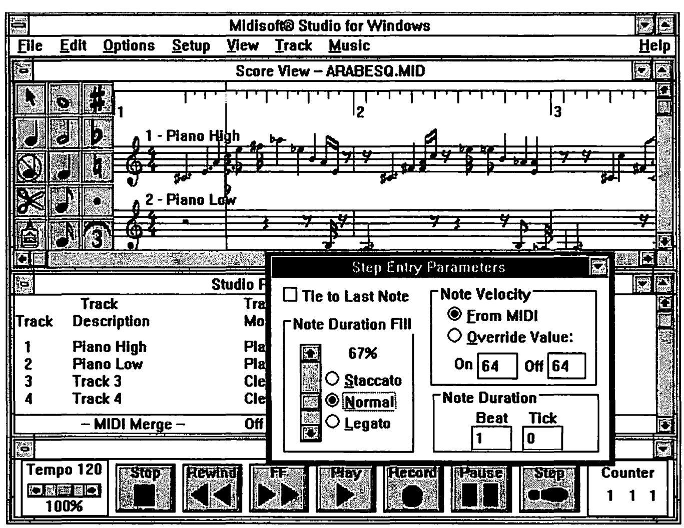
MIDI interface

The MIDI interface is a special connector over which MIDI data is sent to a MIDI device (MIDI OUT), or received from a MIDI device (MIDI IN). This usually connects to the joystick port of a sound card, and may in turn contain its own joystick port.

The MIDI interface allows the use of MIDI devices, such as synthesizers for reproducing songs and keyboards for entering songs. Sequencer programs can also create MIDI files.

These programs usually display an organ-like keyboard on the screen. You can use your mouse or computer keys to "play" the organ-like keyboard. You can record your own compositions and store them in MIDI format.

For example, Midisoft Studio for Windows is a powerful sequencer program that can help you record keystrokes from an external keyboard (real time sequencer) and edit complete MIDI files, note-for-note, on the screen (single-step sequencer).



The different views in Midisoft

MIDI files can subsequently be edited by any program that processes the MIDI format.

TIP

Some sound cards allow you to use a CD-ROM drive, usually by means of an integrated AT bus on the card. In other cases, a CD-ROM drive is connected through a SCSI interface, which requires an additional controller.

It's also possible to connect a CD-ROM drive to a sound card so audio data is played over the sound card directly.

Sound reproduction

Built-in amplifier

Another factor to consider when evaluating sound reproduction capability is power, which is measured in watts, as it is for stereo systems.

Typical sound cards deliver from 1 to 6 watts per stereo channel at 4 ohms. Although this doesn't sound like much, it's actually quite sufficient. Most stereos, even the less expensive ones, are capable of at least 35 watts per channel. However, only 1 to 2 watts are needed for normal room listening volume.

Another measure of sound reproduction capability is the number of synthesizer voices that can be produced per stereo channel. The process of frequency modulation can generate some very pleasant synthesized sounds.

In frequency modulation, the electrical oscillations that represent a sound can be adjusted, thus generating a different type of sound. Although this process may seem complicated, it's easily accomplished with the proper software and hardware. Most sound cards offer 11 voices per stereo channel.

The special FM chips found in sound cards (e.g., Yamaha) create the familiar background for many games and other synthesizers.

MPC specification

The following lists the major sound card requirements of the MPC standard:

Sound Card Requirements
External connections
Microphone
Speakers / headphones
Stereo system
MIDI devices
CD-ROM drive

Sound Card Requirements
Input and output
Built-in amplifier
Synthesizer
Stereo channels
8-bit DAC / ADC (16-bit recommended)
22.05 KHz sampling rate (44.1 KHz recommended)

CD-ROM drive requirements

A CD-ROM drive must meet certain performance specifications for data transfer to qualify for the MPC seal. However, the minimum transfer rate required by the MPC definition (150K/sec) produces disappointing results in animation. The motion will look jerky if your CD drive cannot keep up with the huge quantities of graphics data involved.

Audio functions

According to the Red Book specifications, a CD-ROM must have audio capability so it can play your conventional audio CDs.

You connect it to your sound card for output. You also need a headphone connector that taps into the audio signal. The volume of the audio output can be adjusted through a separate volume control, which is usually located on the front of the CD-ROM drive.

Access time

Mean access time cannot exceed 1 second. This is slow when you consider that large hard drives work with access times of under 20 ms. Even floppy drives are faster.

Data transfer rate

Another measure of data access speed is the data transfer rate. According to the standard, the minimum is 150K per second. Hard drive controllers operate with transfer rates of 250 - 500K/sec (the MFM process) and 600 - 900K/sec (the RLL process). Using a SCSI interface, it's possible to achieve parallel transfer rates as high as 4 Meg/sec.

The size of the data block read must be at least 16K. The execution time cannot exceed the time required to read a data block into the CD-ROM buffer.

Here a data transfer rate of 150K/sec would yield a maximum CPU efficiency of 40%. We recommend that the drive have a 64K data buffer.

Driver software

An appropriate system driver is required for the operating system to recognize the CD-ROM drive. MSCDEX.EXE Version 2.2 meets this requirement. This driver implements the extended audio functions of the API.

Alternatively, the CD-ROM XA (Extended Architecture) can be used, in which audio data is stored separately from other data. This makes it possible to read audio data and video data, for example, in parallel.

Data security

Another specification involves the data security of a CD-ROM drive. The standard requires a minimum MTBF (Mean Time Before Failure) of 10,000 hours. This means that an error can be expected to occur after an average of 10,000 hours.

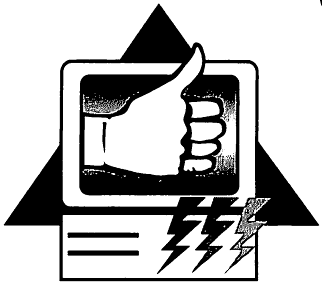
Of course this is just an average, and absolute safety can never be guaranteed. You could be unlucky and have trouble after only five hours. However, generally, the higher the MTBF value, the more reliable the drive should be.

MPC specification overview

The following is a summary of the key features of a CD-ROM drive as defined by the MPC standard:

CD-ROM Drive Key Features

Features
Data transfer rate of 150 K/sec
Mean access time of 1 second or less
Headphone output
Separate volume control for headphone output
CPU access less than 40%
Audio function (CD - DA)
MTBF of 10,000 hours
MSCDEX.EXE driver support, Version 2.2



CHAPTER 10 Preventative Maintenance

To ensure that your system operates flawlessly for as long as possible, you must take care of it. This involves avoiding some harmful actions and performing simple maintenance measures regularly. These measures help minimize wear and tear on your PC and prevent major defects caused by dirt buildup on various components.

You may have already encountered a common problem. After a certain amount of time and use, some diskettes that previously worked flawlessly can no longer be read correctly. The symptoms of this problem seem to indicate mechanical problems.

However, this problem is caused by dirt buildup, in this case, on your drive's read/write heads. This problem occurs more frequently with computers that are exposed to tobacco smoke.

In this chapter we'll discuss the problems that can occur because of different conditions. Besides dust and smoke, other sources of problems include temperature changes, magnetic fields, and moisture.

However, remember that not all PC components are affected to the same extent by these different factors. For example, obviously keyboards and mice are subject to higher physical demands and external influences than, for instance, hard drives.

Your PC's two arch-enemies: Nicotine and dust

If your PC sits, unused, in a corner of a room, its housing will be covered with a layer of dust if it isn't cleaned regularly. The unused PC's interior will remain relatively free of dust because not many dust particles can enter the PC through its vents.

However, the interior of a PC that's used several hours a day will soon be completely covered with dust. The fan unit in the power supply pulls warm air out of the PC interior.

As a result, fresh air enters the PC housing through its openings, carrying with it dust and other particles, particularly nicotine.

Since floppy drives aren't sealed units, air and dirt enters through their openings as well. Dust particles and nicotine are deposited on the drive's read/write heads, where these substances will eventually affect the drive's operation.

The dust layer causes heat buildup

Humidity can cause the coating of dust on the inside of your PC to form a type of insulating layer. This leads to heat buildup in the PC's components. Excessive operating temperatures can shorten the life span of semiconductor components, or even destroy them.

CAUTION

Excessive temperature changes are never good for your PC. The ideal temperature range for operating personal computers is between 65° and 75° Fahrenheit. Too much heat can easily destroy electronic components or the processor and coprocessor chips. These components are designed for a constant operating temperature range.

Math coprocessors are particularly sensitive in this respect. Even a slight temperature increase in a PC tower case situated over an under floor heating system may lead to hardware damage. In this case, a coprocessor might first return incorrect values and eventually will not function.

Hard drive systems using high data densities, for example RLL or ARLL systems, may produce read errors at excessively high or low temperatures. In these instances, the temperature extremes simply cause the data carrier to expand or contract too much.

Moisture and liquids

Under normal conditions, liquids usually never come in contact with the interior of your PC. However, when working on your system's hardware components, there is always the chance that something will be spilled on your open PC.

Despite warnings not to place food or drinks near PCs, most PC users still place coffee mugs and other drinks dangerously close to their PCs. So, unfortunately, accidents can happen, and something can be spilled onto your PC motherboard.

If an accident does occur, never try to dry the wet components with a hairdryer. Although this method will eventually dry your hardware, it may also destroy components through overheating. Disassemble your PC into its individual components, gently dab them with a lint-free cloth, and allow them to air-dry for several days.

TIP

Whenever you're transporting your system over longer distances, we recommend placing a small bag with moisture absorbing material, such as silica gel, in the interior of your PC.

You may want to fasten this bag to the interior using tape or an elastic band. This will keep the bag from jostling components and expansion cards.

You should also follow this tip when you store your PC in the trunk of your car overnight. Then any moisture that condenses inside the PC will be absorbed.

Such bags of moisture absorbent material are usually available at camera supply stores or electronics and computer stores.

CAUTION

Never immediately switch on a computer which was exposed to cold temperatures and then returned to a heated room. Wait at least thirty minutes (preferably longer) to allow any condensed moisture of your PC to evaporate. Also, you should allow the components to reach room temperature before switching on the PC.

Unlikely: corrosion inside the PC

Over longer periods of time, excessive moisture or humidity levels will corrode metal surfaces. Corroded cable contacts are extremely rare in PC systems; they usually occur only under very poor conditions.

However, corrosion results in error symptoms that are usually very difficult to diagnose. Usually these symptoms will be intermittent (one time it works, another time it doesn't). You should check your system's cable connections for corrosion once in a while.

Magnetic interference

Your PC and its peripherals are very susceptible to interference by strong magnetic fields, which can be produced by other electronic devices. Insufficiently shielded power supplies, for example, produce such magnetic fields. These can, for example, cause your monitor's picture to become blurred, perhaps when a laser printer is placed too closely to the monitor. Poorly shielded printer cables that are in close contact with electrical power cords may also result in faulty printer output.

These magnetic fields can also destroy information stored on data carriers. Therefore, do not place your diskettes, data cassettes, or streamers near any source of magnetic fields, such as the computer's power supply, not even for short periods of time.

Even screwdrivers with the otherwise practical magnetic tips are perfectly capable of destroying your DOS diskettes. So always keep these at a very safe distance.

A more recent problem has arrived with the advent of sound cards. The amplified speakers available for sound cards also generate magnetic fields. So, use care in placing these speakers, avoiding diskettes and other data carriers.

Preventive maintenance and care

Personal computers are almost completely maintenance-free devices. However, there are a few simple maintenance and care measures that you can easily perform yourself. Simply make a habit of thoroughly cleaning your PC system twice a year.

Cleaning the interior

The best way to clean the interior of your PC is with a fine brush, similar to the type of brush used to clean paintings. Clean the motherboard thoroughly with this brush. For hard-to-reach places, you may want to use a can of compressed air with a long nozzle tube. You can find this product in most electronics stores. This makes it easy to remove dust anywhere in your system. Never wipe PC components with moistened cloths. Use only dry methods of removing dust from your PC.

Also, clean the exterior of your system's power supply unit. The holes in the unit's casing collect a large amount of dust and nicotine. If these holes become clogged, the PC's ventilation system won't work properly. This can lead to heat buildup and, ultimately, hardware damage. The fan blades and screen can also be cleaned using either a brush, compressed air, or a cotton swab.

Floppy drive maintenance

Like all PC components that rely on moving mechanical parts, disk drives are susceptible to wear and tear. Regular maintenance can increase their life span considerably. Remove the drives from your system and use compressed air to thoroughly blow all dust deposits from their interior. Before re-installing the drives, use a cotton swab dampened with rubbing alcohol to gently clean the read/write heads.

Be careful not to bend any components, and do not open the drive housing under any circumstances. You should always keep your diskettes in their dust sleeves. Also, try to keep the area around your drives clean so that the heads don't become dirty too quickly.

Hard drives are maintenance-free

Hard drives are absolutely maintenance-free PC components. They are hermetically sealed so that contaminants like dust or nicotine cannot enter the hard drive. You can minimize the chance of hard

drive surface damage by preventing sudden movements or shocks to your PC.

When you must move your PC, ensure that the hard drive heads are parked. You can use a special program to do this. This program moves the drives read/write heads to a position where they cannot contact the disk surface, also known as the landing zone.

Such programs are frequently called PARK.COM or SHIPDISK.EXE. Manufacturers of brand-name PCs usually include a hard drive parking utility program on their diagnostics diskettes.

Newer hard drives (i.e., AT bus models) don't even need to be parked. These types of drives automatically park their heads as soon as the power to the system is switched off (auto head lift).

SMARTDRV.SYS saves wear

Another way to prevent premature wear of your hard drive is by using a cache program that optimizes hard drive access. The SMARTDRV.SYS driver is a program included with the MS-DOS operating system.

This driver significantly reduces the number of necessary hard drive operations. Therefore, the hard drive's life span increases.

Use your semi-annual PC cleaning as an opportunity to check all the cable connections within and outside your PC. Make sure that the cables are seated securely and clean any contacts that show signs of corrosion. Unused connectors of free cables should be covered with electrical tape to prevent contamination and dirt buildup.

Keyboard and mouse maintenance

A frequently-used keyboard is obviously subjected to a high level of mechanical stress. However, all kinds of debris also fall into the interior of the keyboard. In order to prevent sticking keys and other keyboard malfunctions, this debris must be removed regularly.

Cleaning the keyboard

One way to clean the keyboard is to turn the keyboard upside down and vigorously shake it. A better approach is to use a can of compressed air to blow out the spaces between individual keys.

The most thorough way of cleaning your keyboard consists of opening the keyboard housing and using a brush to thoroughly clean the keyboard interior. The keyboard housing and the actual keys can be cleaned using a cloth dampened with water and very mild detergent. Some users also find household window cleaner with ammonia an effective cleaner for keyboards.

The keys on original IBM keyboards can be pulled off, which makes it very easy to clean the keyboard. If any liquids enter the keyboard, be sure that it dries out completely before using it again.

Another device that's an integral component of a PC system is the mouse. Mechanical mice are the most common. These mice use mechanical means to transform the movement of the mouse into electronic signals, through a roller ball that contacts the table or desk surface.

As it moves across a surface, this ball picks up dirt and dust, which ends up in the interior of the mouse. Eventually, this buildup of dirt and dust affects the mouse's operation. To minimize this problem, be sure the surface, on which you use the mouse, is clean. Using a mouse pad, for example, is very helpful.

Mouse cleaning

On the bottom of your mouse you'll find a disk that can be rotated to release the roller ball from the housing of the mouse. Clean the ball regularly using a damp cloth. The small rollers, on the inside of the mouse, that contact the roller ball can be cleaned with cotton swabs and rubbing alcohol.

Monitor cleaning

The monitor should also be included in your regular PC cleanings. Make sure that your monitor is switched off when you clean it. Simply use household glass cleaner to clean both the screen and the monitor housing. Always spray the cleaner onto the cloth rather than the monitor, to prevent the liquid from entering any openings or crevices in the monitor.

CAUTION

Never open your monitor housing under any circumstances. The interior of your monitor houses a high-voltage power supply that stores enough energy to cause serious injury or even death. If you believe that your monitor requires maintenance, take it to a qualified repair shop.

Software maintenance

In addition to your PC and its components (hardware), your software also needs regular maintenance. You should make program and file maintenance a routine task. Occasionally check through the contents of your hard drive and determine which files are still needed and which can be deleted. Deleting files not only creates more room on your drive, but also makes it easier to organize your files.

Many programs, such as Microsoft Word, automatically save backup copies of their data files, usually with the .BAK file extension. Although this is a fairly practical function, it requires a lot of disk space.

Temporary files, which are also created by the normal operation of many different programs (recognizable by a .TMP extension), can also be deleted regularly.

COMPRESS and SPEEDDISK

Reorganize your files regularly. The two most common utility programs for hard drive file maintenance, PCTools and Norton Utilities, both offer several software tools that simplify this task.

The Compress (PCTools) and SpeedDisk (Norton) programs compact the contents of your hard drive, thereby creating more disk space. They also organize your drive's directories according to the criteria you specify. Well-structured directories also help speed up hard drive operations.

Computer viruses

Because of the increasing number of PC users sharing data and using world-wide networks and electronic mail systems, computer viruses have become a serious problem for almost all PC users.

As you probably already know, many viruses don't become active immediately after infecting a program. Instead, they remain dormant for a certain period of time. Usually their task is to become resident in the PC's memory when their host program is activated, so programs that are executed later can also be infected.

The virus is activated only after a certain period of time, through the combination of several predetermined factors, such as the date (Michelangelo virus) or simply the tenth time the host program is started. The outcome of viruses range from the funny to the downright destructive. This range includes crumbling screen pictures with raining letters as well as the irrevocable destruction of all hard drive contents.

CAUTION

Since viruses are simply clever programs, they take up space on the diskette on which they are residing. Therefore, when a virus attaches itself to a program file, that file's size increases. The unexplained increase in a program file's size always indicates a likely virus. If you're not checking file sizes regularly, the viruses go undetected. However, not only program files can be infected, but any type of file type.

Printing your directories

You may want to print out a hardcopy of the directories on your hard drive at regular intervals, and compare them with previous printouts. This is a very simple way of detecting viruses that may have infected your hard drive. The same method can also be used on diskettes.

To obtain a hardcopy of any directory, simply reroute your screen output to the printer using the following DOS command:

```
DIR > PRN
```

You may also use "LPT1:" or "LPT2:" instead of "PRN", depending on which parallel port your printer is connected to.

Anti-virus programs

Today, there are a countless amount of computer viruses and new ones are being created daily. The effectiveness of a "virus killer" depends on how up-to-date it is on the new viruses. Therefore, you should purchase virus protection software only from manufacturers who update their products regularly. Be sure to compare how frequently different manufacturers update their virus protection programs when looking for this type of software.

Virus killers

In the past, anti-virus software was criticized because, although it could find viruses, it couldn't reliably eliminate them. However, this criticism is no longer true.

Most professionally developed anti-virus programs completely destroy viruses and, most importantly, don't damage the contents of the host file. These programs are usually easy to use and some even support mouse operation.

Effective virus protection

Although there are no fail-safe methods of virus protection, you can minimize your computer's chance of contracting a virus by following some guidelines.

1. Only use original software

The best way to prevent virus infections is to use only data carriers that are write-protected by the manufacturer. On 5.25-inch diskettes, this write protection is irreversible. The slot on the side of the diskette, which must be exposed in order to write to the diskette, is simply missing.

If such a diskette is copied while a virus is resident in the PC's memory, the copy will be infected with the virus. Most likely this infection will be completely unnoticed.

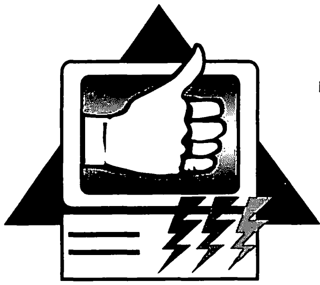
If your system is ever infected with a virus, you must reinstall your software without contracting the same virus again. This is when the software's original diskettes are invaluable.

Often you can purchase used software. You can usually save quite a bit of money by buying programs this way. As long as the software is on original diskettes, with the irreversible write-protection we mentioned above, it should be safe.

2. Never let others use your PC, for example, to make copies of diskettes. If the files being copied are infected, your system will also be infected. Always think twice about placing an unknown diskette in your floppy drive. This is exactly the way that viruses, just like other programs, get onto your hard drive.

3. Avoid downloading software through your modem, from other PCs or from mailboxes. This is how the majority of computer viruses are transmitted.

You must make informed decisions about how to use your system. You can ensure virus protection for your system only if you don't allow third parties to use your computer and if you use only original programs.



CHAPTER 11
Troubleshooting

Although your computer is probably reliable most of the time, most likely there will be times when it won't work properly.

Obviously, a computer breakdown can be very annoying because it interferes with your work. For example, you may not be able to print any documents or access important information from your database.

However, having a system for locating errors can be very helpful. With this system, you could find the source of an error and perhaps correct the problem. In many cases this is possible even if you don't know much about the technical aspects of your computer.

Unfortunately, this process is a lot more difficult than it may sound. Computers are complicated and sensitive machines. So, solving problems can be time-consuming and frustrating.

One reason why it's difficult to locate errors on computers is that a symptom doesn't always lead to the cause of a problem. For example, printer output from a defective printer port could cause formatting problems.

Also, a keyboard problem could cause the computer to "hang up" during booting. Or you may think there is a hard drive error because the hard drive control LED is flashing.

Actually, most errors, even obvious ones, can have completely different causes than their symptoms indicate. It's important to remember this when you're trying to locate errors, even when you're using a specific system.

11.1 Possible Causes

Genuine defects

Errors caused by genuine defects involve defective electronic components. For example, a defect in an expansion card, the CPU, RAM, or another component of the motherboard, etc., can cause the error.

Camouflage and deception

Genuine defects don't occur very often. However, of all the possible errors, these errors are the one most likely to fool users (i.e., they usually cause problems in areas for which they aren't even responsible).

So, these defects make it very difficult to find the source of the error.

Cable problems

The flat ribbon cables used to connect disk drives and hard drives are very sensitive. Additional connections can often cause loose contacts when the PC heats up. This results in drive problems.

Printer and mouse cables

If your printer or mouse stops working, a defective printer cable or mouse cable is much more likely to be the cause of the problem than the printer port or mouse port.

Improper installation or configuration of expansion cards

Fortunately, this type of error usually occurs immediately after you install the expansion card. So, it's fairly easy to diagnose.

Usually specific jumpers for setting port addresses, IRQs, or DMA channels are incompatible with other components in the system that have the same settings.

Physical installation

Another cause of errors is an incorrectly installed expansion card. For example, the card could shift when you screw it into the slot.

Also, you could try an "impossible" configuration, such as installing a second combination controller that isn't designed to be

a second controller (i.e., the controller is intended for use as a first controller).

CMOS SETUP problems

One of the most common causes of problems involves CMOS SETUP. Usually the problem is caused by an old accumulator or an empty battery, which results in the loss of all the setup data. The PC can no longer recognize the hard drive, so the system cannot be started.

Entering the wrong drive type or video adapter can also cause problems.

It's especially difficult if the system BIOS has an advanced SETUP (usually AMI BIOS) that changes the bus clock or the RAM Refresh. AMI's ADVANCED CMOS SETUP allows settings that will completely lock up your computer.

The only solution is to delete all the CMOS data, either by holding down Ins when you switch on the computer, or by discharging the accumulator (there is a jumper on the motherboard for doing this).

It's difficult to differentiate between these types of problems and genuine defects.

Software problems

When the programs are at fault

Software that has been installed incorrectly, used incorrectly, or is simply defective can cause almost any kind of error. These errors can range from write errors on a disk drive or hard drive to a memory parity error, which causes a system crash.

It's almost impossible to analyze software problems. This is mainly because there are so many different programs, and because programs behave differently, depending on the computer configuration.

Also, software viruses can change these programs in many ways. So, we chose to discuss only hardware errors in this section.

11.2 Finding the Source of Errors

As you saw in the previous section, many errors can be divided into categories based on their source. However, what do you do when a problem has several symptoms but you can't determine their sources?

Changing the CMOS battery causes problems with the mouse

We'll use an example to demonstrate how difficult it can be to find the source of a problem.

Suppose that your mouse suddenly stops working. You can't think of a reason why this could happen other than that your mouse is defective. So, you purchase a new mouse from your computer dealer.

However, when you get home and try this mouse, it doesn't work either. Since defects can occur even with new products, you assume that something is wrong with the new mouse and return it to your dealer to exchange it for a different mouse.

However, the second new mouse doesn't work, either. By now you're becoming suspicious and have a feeling that the mouse isn't the cause of your problem. So you return to the computer dealer with the second mouse and your original mouse. Your computer dealer checks both of these mice with his own computer and discovers that they both work.

So, nothing is wrong with the mice, and you haven't made any changes to your software or hardware configuration, except for installing a battery. This means that something must be wrong with the serial port.

When you open the computer to replace the interface card, you notice that battery box, which is taped to the power supply with electrical tape, is very close to the interface card.

When you installed the battery you didn't make any changes to the expansion card. However, you remember that you disconnected one of the flat ribbon cables to find the contacts for connecting the external CMOS battery to the motherboard. Then you plugged the cable back in, just as the cable from the second serial port was plugged in.

However, the interface card didn't contain any information about how the flat ribbon cable should be plugged in. So, you realize

that you may have plugged the cable in incorrectly. When you turn the cable around and plug it back in, the port works again.

Error already existed

The cable of the second serial port was also plugged in upside down. Most likely it was like this when you purchased the computer. However, you didn't notice this because you didn't use the second port.

Study the problem and experiment

This example illustrates two basic problems in identifying and eliminating errors on PCs. First, it shows that it's helpful to try out components, which you think are defective, on another computer before replacing them. However, not many users have access to more than one computer.

The example also shows how important it is to consider the source of the error from all different points of view. The source of the error can be in an entirely different area than you might have first guessed.

To save yourself from time-consuming repairs like the one in the example, especially ones that are expensive, ask yourself the following questions before you take any action:

1. When did you first notice the error?

For example, did you notice the error after installing software, moving the PC, etc.? The answer to this question may help you find the solution to a problem, especially if the change doesn't seem related to the problem.

2. When exactly does the error occur?

Knowing when the error occurs (e.g., before, during, or after the booting process), can also help you find the source of the problem.

3. Can you reproduce the error?

Try to accurately describe the conditions under which the error occurred. A time error that takes place before the computer warms up will definitely have a different source than an error that always occurs after you call a program (e.g., a specific DOS command).

4. What does the error look like?

Being aware of the computer's other actions when an error occurs can also help you find the source of the error. For example, the number and duration of beeps that sound when you switch on your computer provides useful information.

Any other changes to the computer can also be important. Does the fan or the hard drive run, do the LEDs light up, etc.?

After narrowing down the sources of the error by answering these questions, you can begin to solve the problem.

Before making any major changes, such as removing a disk drive, always check all the cable connections and how these connections fit together. This usually saves you a lot of work.

Borrow replacement parts

If you can borrow PC components, start by replacing the parts you think are defective.

Remove all your components

If replacement parts aren't available, you might be able to solve the problem by removing all the components that aren't needed to run the computer or the components that obviously have nothing to do with the error. Sometimes removing such a part also removes the error.

CAUTION

As with all actions on the computer hardware, the advice we gave at the beginning of Chapter 6 applies here. Above all, **never** change anything while the power supply is switched on, and always ground yourself. After all, we want to eliminate errors, not cause new ones.

11.3 Common Errors

In this section we'll provide an overview of the most common errors, based on their symptoms. We'll try to use these symptoms to determine the source of the error as accurately as possible.

Unfortunately, because of the difficulties described, we won't always be able to do this. It's also possible that your symptom won't appear in the following list because there are so many possible sources. In these instances, a description of a similar problem may help.

Did you make any changes?

After making changes to the computer, such as installing expansion cards, you may want to refer to the section or chapter of this book that discusses the change. You may have made a mistake or overlooked something.

Errors after startup

You switched on the computer, the screen stays dark, the fan and hard drive won't run, LEDs don't light up

If the power supply cord and the outlet are working properly, most likely there's problem with the power supply.

Power supply defective?

To determine whether the power supply itself is defective or some other computer part is causing a short circuit, you must open the computer (not the power supply).

Then separate each component, one by one, from the power supply. Each time you do this, switch the computer on and off to check whether the fan for the power supply works.

Test the components

Start with the floppy drives and then continue with the hard drive(s). If the fan begins running again, reconnect the last component and switch on the PC again. If the fan no longer works, the device probably has a short circuit. So it must be replaced or repaired, which usually isn't worth it.

Don't run the power supply unloaded!

If you still haven't found anything, separate the motherboard from the power supply next. Before switching on the computer, make sure you reconnect something to the power supply. It's best if you connect a hard drive. You cannot run most power supply units unloaded.

Power supply defective!

If the fan still won't run, your power supply unit is probably defective. Remove it from the computer and take it to your computer dealer for a second opinion.

Error on the motherboard

However, if the vent starts running and the hard drive you connected also works, the error is on the motherboard. Reconnect the motherboard (switch off the power supply first), remove all the expansion cards, and switch on the PC each time you remove a card to check for improvement.

If you still haven't eliminated the short circuit after removing the last card, then the motherboard itself is the source of the error. Ensure that the power supply runs without the motherboard connected and then remove the motherboard.

Usually it's cheaper to exchange the motherboard than have it repaired, especially if the memory components and the CPU can still be used.

Computer beeps, fan runs, screen stays dark

The beeping is an error message from the Power-On Self-Test (POST). The POST beeps because the system error is so serious that even simple screen output is no longer possible. You can identify the different errors by the duration and number of beeps. At the end of the chapter, you'll find an overview of these acoustical error messages.

One or more three digit or four digit numbers appear on the screen, computer stalls

It's the POST

This is also a POST message. The numbers are codes for different hardware errors. You'll also find a list of these codes at the end of the chapter.

Computer stalls while counting memory, no error message

This error generally occurs only on compatible devices whose POSTs don't produce error messages.

If the cause of the error is a defective memory component, the computer will always stall in the same place. If the motherboard has a defect, the computer could also stall at different times.

Wrong setting for memory expansion card?

If your computer has a memory expansion card, remove it. If this eliminates the error, either the expansion card is defective or the memory starting address is configured incorrectly, which may conflict with the memory on the motherboard.

Refer to the expansion card's installation information for the correct DIP switch or jumper setting.

Computer counts too little memory (e.g., 896K instead of 1024K) but otherwise works well

Stolen memory!

This is probably not even an error, but simply a result of using shadow RAM.

When you use shadow RAM, a part of the expanded memory is reserved for data from the BIOS ROM and the video BIOS. The speed advantage gained by using shadow RAM during the boot process and in picture construction usually makes up for the slight memory loss. Otherwise, some versions of SETUP have a special option that let's you disable shadow RAM.

Screen stays dark, cursor in upper-left corner, no error message, computer eventually boots (performs drive test and accesses hard drive)

Second graphics card?

It's possible that the mono/color jumper for configuring the graphics card is set incorrectly.

You may have changed graphics cards or added a second graphics card, but not informed the motherboard of this change.

Set the Color/Monochrome jumper to the other position or configure your graphics card, according to the manufacturer's specifications, as the first or second adapter.

For more information about installing a different or second graphics card, refer to Section 7.8.

"CMOS Configuration Error" or similar message, computer beeps and stalls

Battery dead?

This error message usually occurs only after you make changes to the hardware, or if the CMOS battery is dead, or old and weak.

The message indicates that the data stored in CMOS don't match the hardware configuration determined during the POST.

Enter the correct data in SETUP and ensure that any jumpers on the motherboard for configuring RAM or the graphics card are in the correct position.

If this error occurs frequently or if you lose the CMOS entries you made, install an external battery as described elsewhere in this book.

Can't boot from the hard drive

Because there are so many possible sources of this problem, it's one of the most common errors. It is also one of the worst errors you'll encounter.

Fortunately, this error rarely indicates a defective hard drive. Instead, most of the problems result from a defective configuration or deleted system files.

Now we'll provide a brief description of a normal case (i.e., we'll list what's needed in order for a hard drive to run perfectly).

Correct CMOS entry

Let's begin with CMOS SETUP. You must set up the hard drive correctly. The number of heads, tracks, and cylinders must match those of the hard drive type you enter in SETUP.

Also, if your SETUP has an entry about the bus clock, ensure that the bus clock doesn't exceed that of a normal IBM AT. Otherwise, the controller may break down, especially with some old MFM systems.

Low-Level Format

Next, you must low-level format the hard drive. The only exception to this is an AT bus hard drive, which is already low-level formatted by the manufacturer. In fact, users shouldn't initialize an AT bus hard drive because it could destroy the hard drive.

Partitioning with FDISK

Prior to DOS formatting, use FDISK to set up at least one DOS partition on the hard drive. This partition should be active (i.e., it must be selected for BIOS as the boot partition).

DOS formatting with system files

The regular DOS format is next. Use the /S switch to transfer the files of the operating system kernel to the boot sector.

Then copy the COMMAND.COM file to the root directory of the boot drive. Some versions of DOS also let you copy this file to a subdirectory and point to it using a COMSPEC entry in the CONFIG.SYS file. In these instances, losing the CONFIG.SYS file is equivalent to deleting the command interpreter itself.

So, to boot from a hard drive, it must be low-level formatted, partitioned, and activated. Also, you must DOS format the hard drive (/S), and provide a command interpreter.

Therefore, before you think about a hard drive error, check all of these requirements by booting your computer from a diskette and then try to access the hard drive.

COMSPEC and CONFIG.SYS

If you manage to access the hard drive, check the root directory for the COMMAND.COM file or determine whether the COMSPEC entry in the CONFIG.SYS file points to this file.

CHKDSK displays the system kernel

Use the CHKDSK program to confirm that the hidden system kernel files (i.e., MSDOS.SYS and IO.SYS) are on the hard drive. CHKDSK displays the hidden files in a list.

Then use FDISK to determine whether there is an active DOS partition.

If none of these solutions work, you have the option of setting up the hard drive again. This involves performing all the steps previously listed, from the entries in SETUP, to creating an active partition and DOS formatting.

Then reinstall your software. Remember that all data on the hard drive will be lost when you do this.

AT bus drives

Another common error occurs with AT bus drives that have different translation parameters. AT bus drives use different SETUP entries that have different capacities.

If you used FDISK to set up an active partition (some AT bus hard drives already have a partition when you buy them) and then

change the entry in SETUP, you may be able to DOS format the drive and transfer system files. However, the boot process will always be canceled.

Therefore, before changing the SETUP parameters of AT bus drives, delete all the partitions on the hard drive and recreate them again later.

The only way to localize a hardware error on the hard drive system (which probably isn't the problem anyway) is to replace the controller and the hard drive. Also remember the possibility of a defective cable.

Everything we said about other serious errors also applies to this situation: Remove all parts from your computer that aren't related to the problem. For example, many PC users have been surprised by the improvements in their hard drives after removing the game card.

Errors during operation

Computer locks up or crashes

Frozen

When the computer "locks up", it refuses to react to anything you try. Usually the contents of the screen are "frozen;" sometimes the screen even turns black. Pressing the Num Lock key won't even toggle the LED. All you can do is reset the system.

There are many causes for this type of computer crash. Pay close attention to the conditions under which the error occurred. For example, a hard drive or floppy LED that's lit can indicate an error in the drive or controller.

Hidden refresh, slow refresh

If you have a hardware BIOS with ADVANCED CMOS SETUP, your system may be crashing because you made the wrong setting in ADVANCED CMOS SETUP. In this case, increase the redraw waitstate if possible, and disable any hidden refresh or slow refresh functions.

Use the default settings!

Usually SETUP has an option in its main menu called "Restore BIOS defaults". This option specifies default settings for all the delicate, tricky options. Don't worry about hurting vital settings like hard drive type or drive size because this option doesn't change those settings.

VGA programs on a CGA card?

If the error keeps occurring in specific parts of a program, it could be a software error. For example, if a program tries to use a coprocessor that your computer doesn't have or a graphics mode not supported by your installed graphics card, a system crash may occur.

The CPU dies irregularly

However, if the problem happens arbitrarily, depending on certain situations, or if the problem seems to be linked to warming up the computer, you probably have a defective CPU, coprocessor, or motherboard.

To narrow down the problem, remove everything from the computer that's not absolutely necessary to run it and determine if anything changes.

Replacement CPU can't be too slow!

Perhaps you can borrow a friend's motherboard or test your computer with a different CPU at a computer store. Remember that the test CPU should also be suitable for the clock speed of your motherboard (i.e., it must be at least as fast as your own motherboard; it can also be faster).

So, you can put a 33 MHz CPU on a 20 MHz board without any trouble. However, putting a 20 MHz CPU on a 33 MHz board will destroy the processor.

SX owners

Owners of 386SX computers usually cannot exchange their CPUs because they are soldered on the motherboard. In this case, you must exchange the entire motherboard.

Parity Error (at Hex .....)

When the computer miscalculates

This error message usually indicates a memory reading error or a checksum error.

When such a checksum error occurs, it triggers a special interrupt that stops the CPU and causes an error message to appear on the screen, usually with the hexadecimal address of the memory component that caused the error.

Thorough interruption

Since it's no longer possible to continue working on the computer, this condition is like "locking up" the system.

Unfortunately, this error message doesn't always indicate a memory error. Actually, almost every component, which has direct

or indirect access to the bus, can trigger such an interrupt. This makes it much more difficult to find the error.

CMOS or memory?

Therefore, follow the same steps to localize the error that we described in the previous section about hanging the computer. First, check your settings in CMOS SETUP, especially the settings for waitstate and refresh. Then start removing components.

Defective graphics card

The RAM installed on your graphics card can also cause memory errors. If you can borrow another graphics card, test it on your PC to determine whether this is the cause.

RAMs too slow

If you get a parity error after putting together a new computer or after putting new memory chips on the motherboard, this usually means that the DRAM access time is insufficient.

"Difficult" SIMMs

Occasionally there will also be problems with SIMM or SIP chips, on which memory modules with different access times are being used. You should be able to exchange these for another brand. Ask your computer dealer for more information.

Both drive lights are on, but the drives don't work

Floppy cable plugged in wrong

This error occurs after you've worked on the drive cable. It occurs because a cable for the 3.5-inch drive isn't plugged in correctly.

Check the floppy cable. It must be connected to the floppy or combination controller with a post connector; the red or blue wire of the 34-pin flat ribbon cable should go to Pin "1". The floppy cable connects to the floppy drives from a card connector (5.25-inch drive) and a post connector (3.5-inch drive).

The end of the cable, with part of the wires twisted, goes to drive A:; the drive selects should both be at DS1. Once again, the labeled wire goes to Pin "1".

The printer won't print

This error, which frequently occurs, can be a problem with the printer, the cable, the PC, or the software. It's usually caused by a defective printer cable or poorly installed software.

Software problem? Try printing from DOS. Either press Prt Sc or use the PRINT command. For example, you could enter PRINT AUTOEXEC.BAT. The printer must be switched on and online.

Printer defective? Then run a printer self-test to determine whether the printer is defective. With most printers, you do this by holding down the Formfeed button, or some other button, when you switch on the printer. Check the printer manual to determine which button you must press to enable the self-test.

Printer cable defective? If the self-test is successful, check the printer cable. Either borrow a cable that works or try printing with your cable on another system.

Printer port defective? If you still haven't found the error, your printer port is probably defective or configured incorrectly. If you have an AMI BIOS, check the system configuration table that appears on the screen after the self test to determine whether the system even recognizes the port.

If you still can't find the error, either the card is defective or it's in conflict with another expansion. For example, a second parallel port on the monochrome video card could be accessing the same port addresses or IRQs. Remove everything from the computer that you don't need and then try printing again.

11.4 Error Messages

BIOS runs a series of tests every time you start the system. For example, BIOS checks the memory, checks for disk drives, and checks the specified parameters to see whether they are correct. The following is a list of the most common error messages.

Acoustical error messages

Acoustical Error Messages

Signal	Meaning
no tone	Power out
continuous tone	Power supply defective

Acoustical Error Messages (continued)	
Signal	**Meaning**
many short beeps	Defective motherboard
1 long	RAM Refresh
1 long, 1 short	Defective motherboard or ROM-BASIC
1 long, 2 short	Video card error or dip switch (XT)
1 long, 3 short	Error on EGA card
2 long, 1 short	Synchronization of monitor adapter
2 short	Parity error (incorrect memory checksum)
3 short	Errors in the first 64K of RAM
4 short	Timer or counter defective
5 short	Processor failure or video RAM
6 short	Error in keyboard processor
7 short	Virtual processor mode set (AT)
8 short	Incorrect writing to Video RAM
9 short	Wrong ROM BIOS checksum

Error messages during POST

Error Messages During POST	
Error	**Meaning**
01x	Non-defined error
02x	Error in power supply
1xx	Motherboard error
101	Interrupt error
102	Timer error
103	Timer interrupt error
104	Defective Protected Mode (AT)
105	Last 8042 command not accepted
106	Converting Logic (Expansion bus) defective
107	"Sticking" NMI
108	Defective bus timer
109	DMA error

Error Messages During POST *(continued)*	
Error	**Meaning**
110	Parity error (PS/2)
111	Defective expanded memory (PS/2)
121	Unexpected hardware interrupt
161	CMOS checksum wrong (AT)
162	Defective configuration (AT-CMOS)
163	Wrong date or time (AT-CMOS)
164	Defective memory size (AT-CMOS)
199	Specified configuration defective
2xx	Memory errors
201	Memory error, address specified
202	Address error, A0 -A15
203	Address error, A16-A23
215	Memory error (PS/2)
216	Memory error (PS/2)
3xx	Keyboard errors
301	Keyboard reset defective or key stuck
302	Keyboard locked
303	Keyboard defective
304	Defective keyboard control
4xx	MDA errors
401	Defective adapter self test, memory error
408	Defective character attributes
416	Defective character set
424	Cannot set text mode 80x25
432	Defective parallel port (PS/2)
5xx	CGA errors
501	Defective adapter self test, memory error
508	Defective character attributes
516	Defective character set

Error Messages During POST *(continued)*	
Error	**Meaning**
524	Cannot set text mode 80x25
532	Cannot set text mode 40x25
540	Cannot set graphics mode 320x200
548	Cannot set graphics mode 640x200
6xx	Disk drive errors
601	Defective disk drive self test
602	Invalid boot sector
606	Diskette change not displayed
607	Write-protect
608	Defective diskette status
610	Formatting not possible
611	Disk drive doesn't react, timeout
612	Defective controller chip
613	DMA error
616	Defective number of rotations
621	Defective positioning
622	CRC error
623	Sector not found
624	Defective address
625	Defective positioning, controller error
626	Defective data compare
7xx	Coprocessor errors
9xx	Error in first parallel port (LPT1)
901	Defective port self test
10xx	Error in second parallel port (LPT2)
1001	Defective port self test
11xx	Error in first serial port (COM1)
1101	Defective port self test

Error Messages During POST *(continued)*	
Error	**Meaning**
12xx	Error in second serial port (COM2)
1201	Defective port self test
13xx	Error in game port
1301	Defective port self test
1302	Defective joystick
14xx	Printer error
1401	Defective printer self test
1404	Defective dot matrix printer
15xx	SDLC adapter error
16xx	Terminal emulation error
17xx	Hard drive error
1701	Defective hard drive self test
1702	Defective controller
1703	Defective hard drive
1704	Non localizable error
1780	Defective hard drive 0
1781	Defective hard drive 1
1782	Defective controller
1790	Defective hard drive 0
1791	Defective hard drive 1
18xx	Expansion card errors
1801	Defective card self test
1810	Defective enable/disable
1811	Defective extender card test

Error Messages During POST *(continued)*	
Error	**Meaning**
1812	Defective addressing
1813	Error in wait state
1814	Defective enable/disable
1815	Error in wait state
1818	Defective disable
1819	Defective wait request
1821	Defective addressing
19xx	3270 PC attachment card errors
20xx	Errors in first BSC adapter
21xx	Errors in second BSC adapter
22xx	Cluster adapter errors (LANs)
24xx	EGA error (on PS/2 VGA error)
2401	Defective adapter self test, memory error
2408	Defective character attributes
26xx	Errors of XT/370
27xx	Errors of AT/370
28xx	Errors of 3278/79 emulation adapter
29xx	Color printer errors
30xx	Errors of first PC network adapter
31xx	Errors of second PC network adapter
33xx	Compact printer errors
36xx	Errors on General Purpose Interface Bus

Error Messages During POST *(continued)*	
Error	**Meaning**
38xx	Data Acquisition Adapter errors
39xx	PGA error
3901	Defective adapter self test, memory error
71xx	Voice Communication Adapter errors
73xx	External 3.5-inch disk drive errors
7301	Defective disk drive self test
7306	Diskette change not displayed
7307	Write-protect
7308	Defective diskette status
7310	Formatting not possible
7311	Disk drive doesn't react, timeout
7312	Defective controller chip
7313	DMA error
7316	Defective number of revolutions
7321	Defective positioning
7322	CRC error
7323	Sector not found
7324	Defective address
7325	Defective positioning, controller error
7326	Defective data compare
74xx	VGA error
7401	Defective adapter self test, memory error
85xx	Expanded memory errors
86xx	Digitizer errors on PS/2
89xx	Music Feature card errors
104xx	ESDI controller errors on PS/2
10401	Defective self test

Error Messages During POST *(continued)*	
Error	**Meaning**
10402	Defective controller
10403	Defective hard drive
10404	Non localizable errors
10480	Defective hard drive 0
10481	Defective hard drive 1
10482	Defective controller
10490	Defective hard drive 0
10491	Defective hard drive 1

CHAPTER 12

Exploring Your System

You may not be sure what sort of equipment your computer contains. Or, you may have a friend who just bought his or her first computer, and has no idea what the new PC has "under the hood." This chapter explains the PCINFO program which you'll find on the companion diskette.

The companion diskette contains many other programs for checking system info, determining cache benchmarks, finding files and more. You'll find information in the Appendix about the companion diskette.

12.1 The PCINFO Program

The companion diskette contains a program called PCINFO. Use this program to display information about your computer and its configuration. You can start this program from the companion diskette, or copy it to your hard drive and start it from there.

We used Borland Turbo Pascal 6.0 and Borland Turbo Assembler 2.5 to develop this program. This section provides an overview of how to use the compiled program.

General information

All the functions can be activated through the keyboard and a mouse, if available. Three buttons appear at the bottom of the information windows. They have the following functions:

Next Page

Activates the subsequent function of the menu or the subsequent menu

Previous Page

Activates the previous function of the menu or the previous menu

Print Page

Prints the displayed page

The Next Page and Previous Page buttons don't affect the first and last pages.

12.2 PCINFO Menus

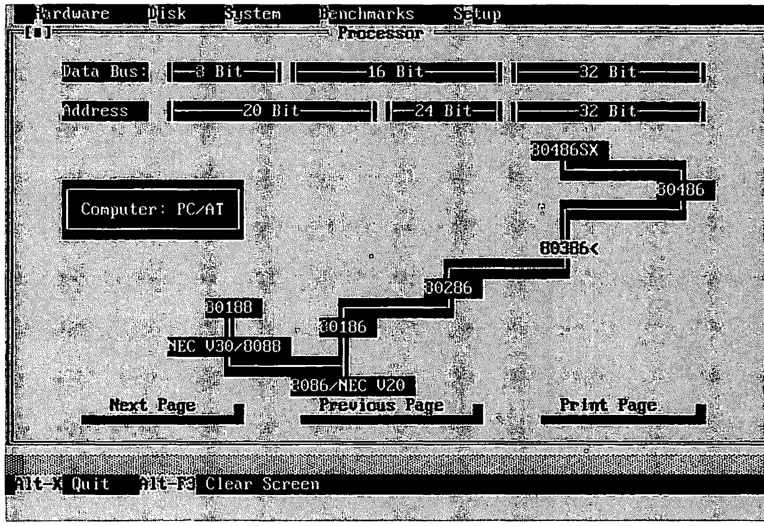
Hardware menu

The **Hardware** menu contains functions that you can use to obtain information about your hardware. These functions include the processor, coprocessor, video adapter, and interfaces.

Processor function

This function provides information about the type of processor in your system and the type of computer being used (e.g., PC/AT, PS/2, etc.). Also, the width of the address and data bus of the microprocessor used in your system is also provided.

The following illustration was created on a 386 PC/AT. The processor designation is indicated by an arrow to the left and a different color. If you have only a Hercules card, this would be indicated only with the arrow. The system type is indicated in the "Computer:" box.



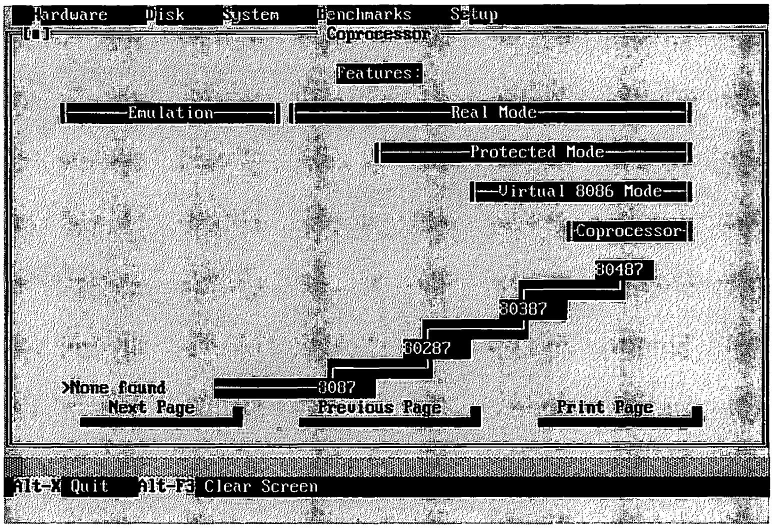
Microprocessor display

Two lines appear above the processor designation tree. These lines are labeled as data bus and address bus. The areas marked in these lines correspond to the processors found below.

For example, the 80386 represents both the data bus and the address bus under the marking 32 bits and actually has a 32-bit wide data bus and a 32-bit wide address bus.

Coprocessor function

If you activate this function with the **Hardware** menu, you'll receive information about a coprocessor that may be installed in your system.

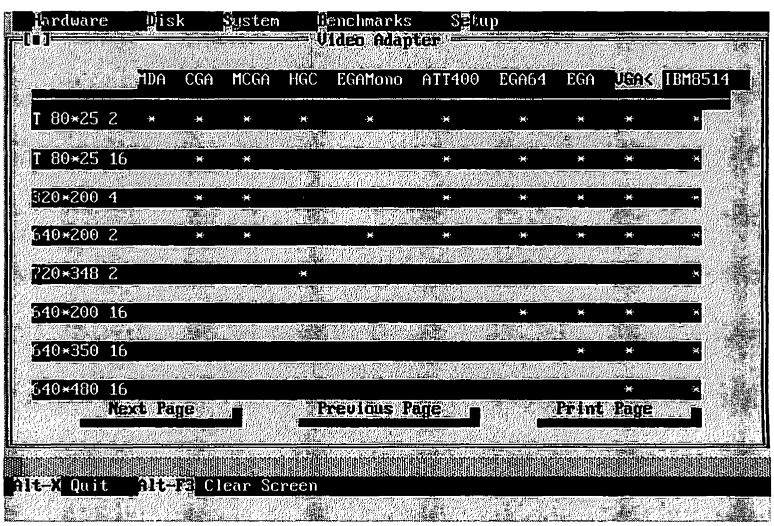


Coprocessor display

Like the **Processor** function, lines also appear in the top portion of the window. In this case, the information refers to the current coprocessor.

Video Adapter function

This function indicates which graphics card your system has and what graphics resolution, as well as text resolution, is possible.



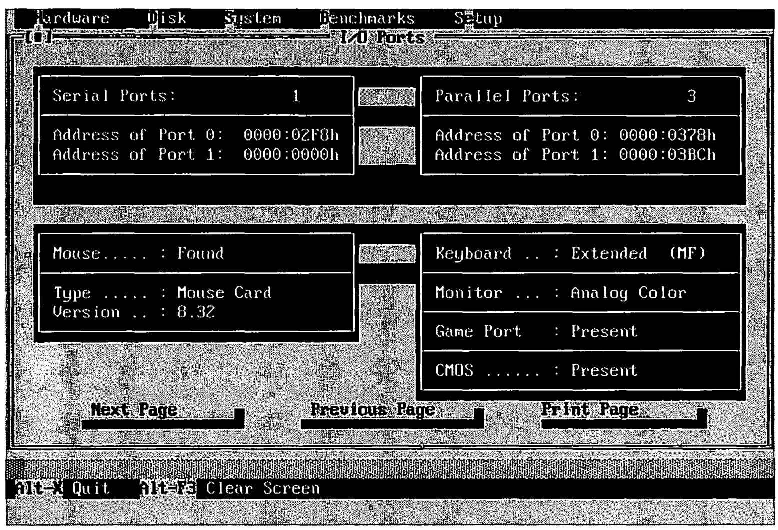
Video Adapters display

The Video Adapters display appears in column format. Each column is assigned to an adapter type, which is indicated by color and an arrow.

If your graphics card is capable of one of the resolutions, which are listed in the lines, this is indicated by an asterisk ("*").

Computer function

This function handles the common computer interfaces, such as serial and parallel, and also the game port, keyboard, and screen. Also, the version of your mouse or the mouse driver is indicated.



Interface display

The display is roughly divided into four boxes. There is a box for the serial interface and a box for the parallel interface. The number of the currently recognized interfaces is displayed and the addresses of the first two ports are indicated in these boxes.

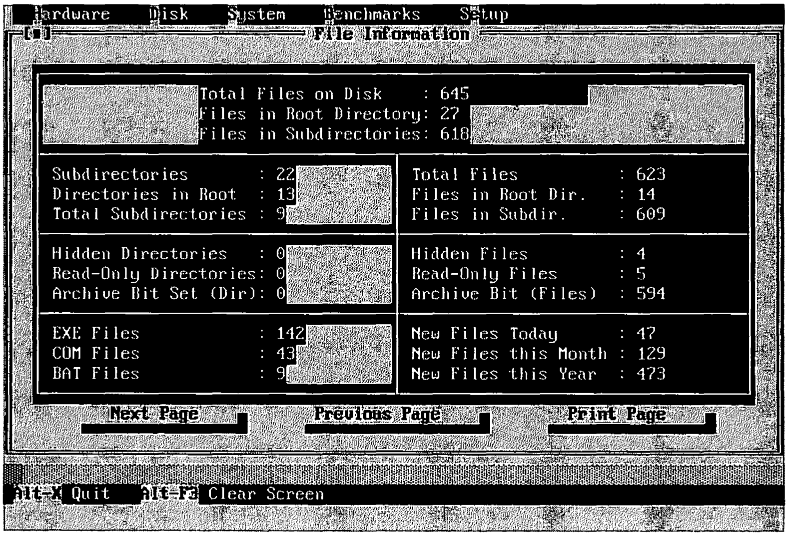
There are also boxes that provide information about the currently installed mouse driver, keyboard, monitor, game port, and CMOS.

Disk menu

This menu contains functions that locate information about the drives.

File Information function

This function displays statistical information about the files currently available on the active drive.



File information display

When this function is activated, the following information is displayed:

Subdirectories

The total number of directories in the current drive.

Directories in Root

The number of subdirectories in the root directory.

Total Subdirectories

The total number of subdirectories on the drive, minus the ones in the root directory.

Hidden Directories

The total number of subdirectories hidden on the drive (hidden bit), including the ones in the root directory.

Read-Only Directory

The total number of the directories on the drive that are protected from changes (e.g., the read only bit is usually ignored). The subdirectories in the root directory are included.

Archive Bit Set (Dir)

The total number of changed subdirectories on the drive (archive bit), including the ones in the root directory.

EXE Files

The total number of files on the drive that have an .EXE extension.

COM Files

The total number of files on the drive that have a .COM extension.

BAT Files

The total number of files on the drive that have a .BAT extension.

Total Files

The total number of files on the drive.

Files in Root Dir.

The total number of files in the root directory.

Files in Subdir.

The total number of files in the subdirectories.

Hidden files

The total number of files hidden on the drive (hidden bit).

Read-Only Files

The total number of files on the drive that are protected against change (read only bit).

Archive Bit (Files)

The total number of files on the drive that were changed (archive bit).

New Files Today

The total number of files whose last change occurred during the current day.

New Files this Month

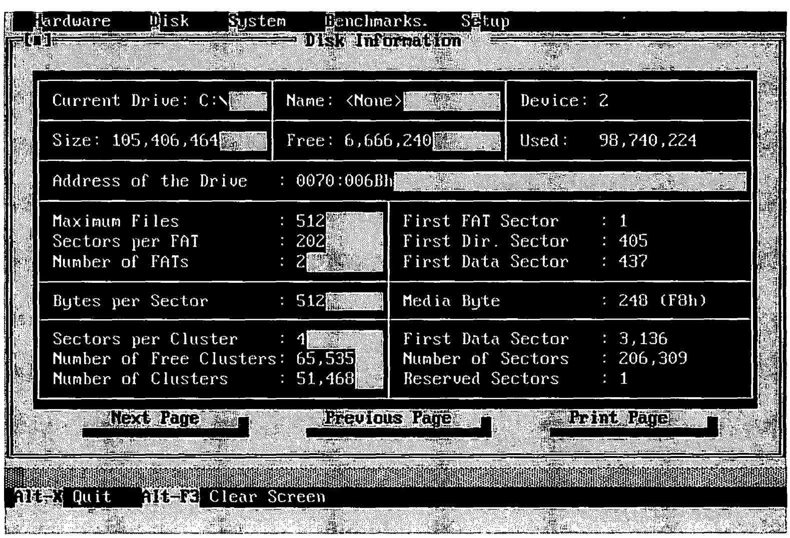
The total number of files whose last change occurred during the current month.

New Files this Year

The total number of files whose last changes occurred during the current year.

Disk Information function

This function specifies the internal parameters of the currently active drive.



Disk Information display

The following information is provided:

Current Drive

The drive to which the displayed information refers.

Name

The name of the current drive (volume name).

Device

The device number of the current drive.

Size

Size of the maximum available memory on the drive.

Free

Available memory that's free.

Used

Memory that's occupied.

Address of the Drive

The address of the driver for the current drive.

Maximum Files

The maximum number of entries in the root directory of the current drive.

Sectors per FAT

The number of sectors needed for a copy of the FAT of the current drive.

Number of FATs

The number of FAT copies.

Bytes per Sector

The size of a sector in bytes.

Sectors per Cluster

The number of sectors per cluster of the current drive.

Number of Free Clusters

The number of free clusters.

Number of Clusters

The total number of clusters on the current drive.

First FAT Sector

The physical sector, where the first copy of the FAT starts.

First Dir. Sector

The physical sector, where the first directory starts.

First Data Sector

The physical sector, where the first data starts.

Media Byte

The media descriptor byte.

First Data Sector

First sector where the search starts.

Number of Sectors

The total number of sectors on the drive.

Reserved Sectors

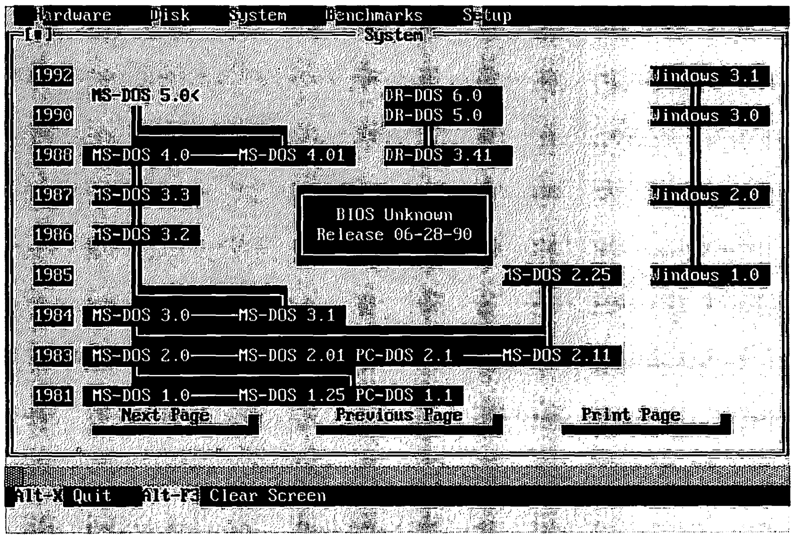
The total number of sectors reserved for system purposes on the drive.

System menu

The functions from this menu provide system dependent information.

Operating System function

This function provides information about the DOS version that's installed. The BIOS used in your system is also indicated.

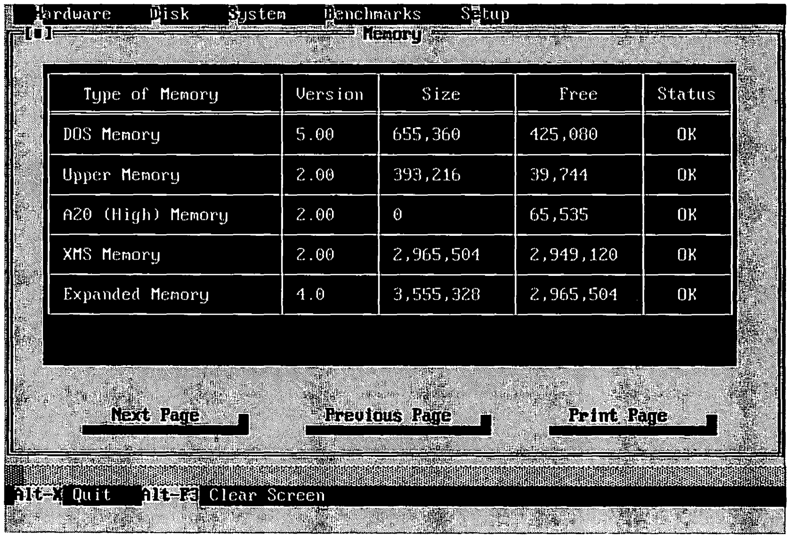


System information display

A display tree, which shows the installed MS-DOS version, appears on the left side of the window. The DR DOS version is indicated in the middle of the window. The installed Windows version is displayed on the right side of the window and the BIOS version is displayed in a box in the middle of the window.

Memory function

This function indicates the types of memory that are available in your system and the version of the driver.



Type of Memory	Version	Size	Free	Status
DOS Memory	5.00	655,360	425,080	OK
Upper Memory	2.00	393,216	39,744	OK
A20 (High) Memory	2.00	0	65,535	OK
XMS Memory	2.00	2,965,504	2,949,120	OK
Expanded Memory	4.0	3,555,328	2,965,504	OK

Memory partition display

The currently available memory and its maximum size are displayed in column format. If a certain type of memory isn't available, the corresponding line remains blank.

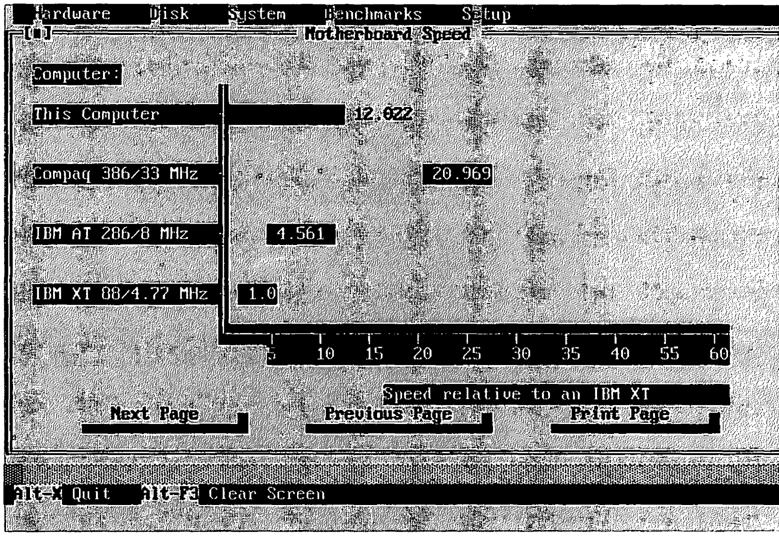
If you use a memory driver, such as QEMM386, the total size of the memory displayed may differ from the actual size.

Benchmarks menu

With the functions contained in this menu, you can determine the speed of your individual system components. Both relative and actual values are displayed.

Mainboard function

Your motherboard is tested for speed. The resulting value is displayed relative to an IBM XT at 4.77 MHz.

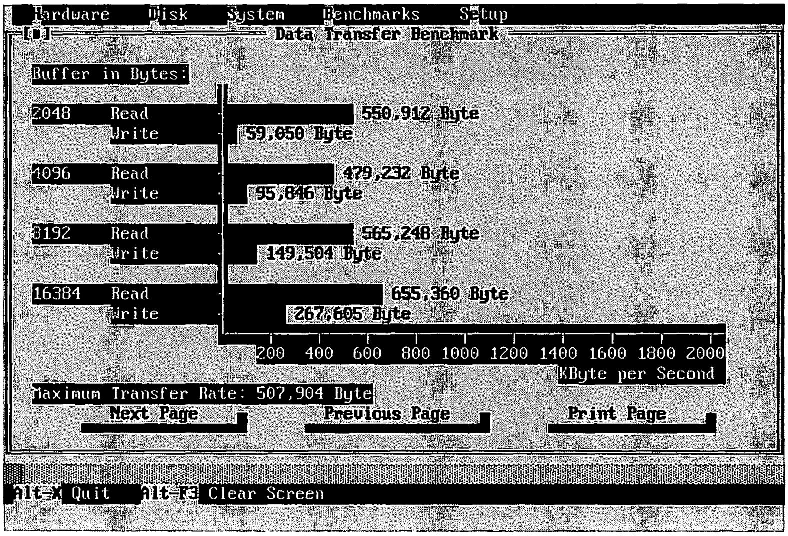


Motherboard speed display

The value for your system is displayed on the first line; if you have a color monitor, these values are highlighted in white. The values for two other computers are also displayed.

Speed function

With this function you can test the speed of your drive. Various values are provided so you can compare them with other computers and other disk systems (RLL, AT bus, SCSI, ESDI, etc.).

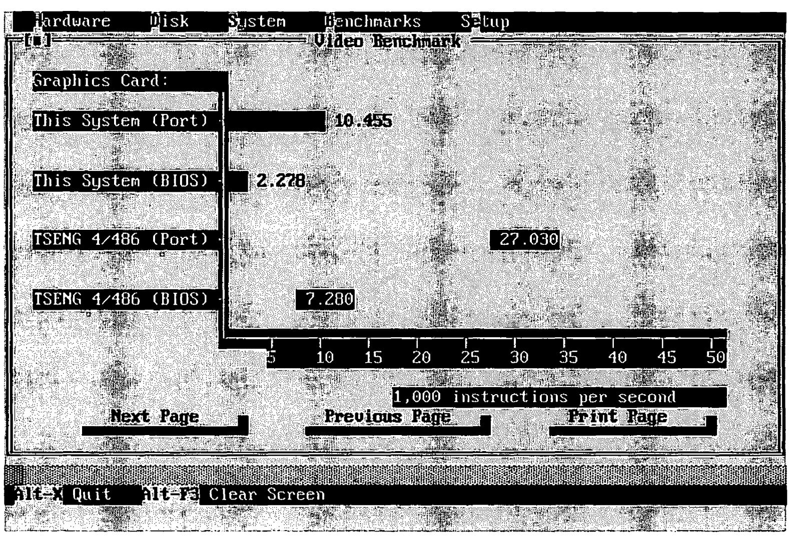


Medium benchmarks display

The benchmark evaluates read and write speed. For better comparisons, it's written and read with four different buffer sizes.

Video function

This function tests the maximum transfer rate to the video card through direct access and also through the video BIOS.

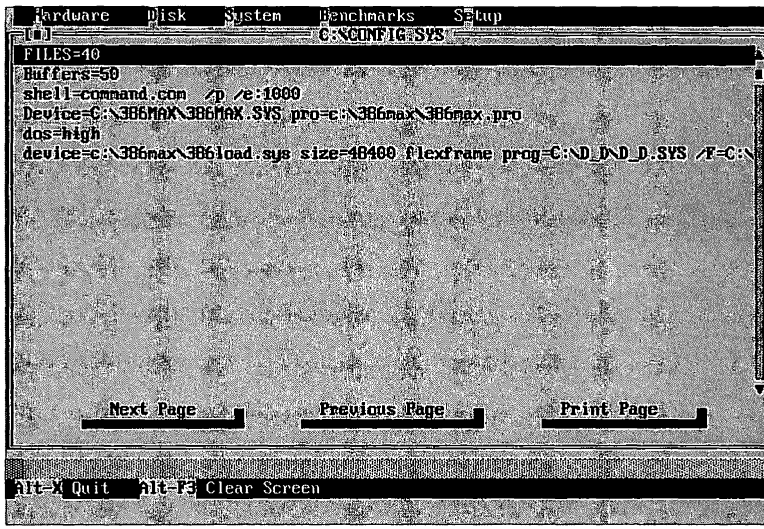


Video Benchmarks display

For comparison, the values for an 80486 with a Tseng ET4000 video card are also displayed. The direct access to the hardware is labeled "Port".

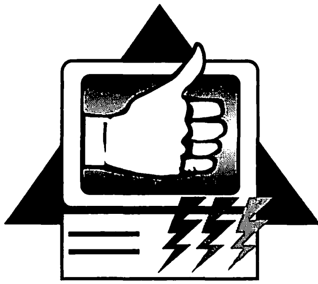
Setup menu

With the functions in this menu, you can display your CONFIG.SYS and AUTOEXEC.BAT files.



CONFIG.SYS display

To the right of the display window is a scroll bar, which you can use to scroll through the text, if it's longer than one display page. You can use the ↑ and ↓ keys to scroll the text line by line and the PgUp and PgDn keys to scroll the text page by page.



APPENDIX A

BIOS Hard Drive Parameters

Appendix A lists the BIOS hard drive parameter tables for several ROM BIOS versions which is useful when you're installing one of these drives. The columns in Appendix A have the following meanings:

Cyl	Cylinder	WPC	Write precompensation		
Kb	Kilobytes	LZ	Landing Zone	Meg	Capacity (Megabytes)

IBM-AT-BIOS Hard Drive Parameters

Type	Cyl	Heads	WPC	Kb	LZ	Sectors	Meg
1	306	4	128	0	305	17	10.16
2	615	4	300	0	615	17	20.42
3	615	6	300	0	615	17	30.63
4	940	8	512	0	940	17	62.42
5	940	6	512	0	940	17	46.82
6	615	4	—	0	615	17	20.42
7	462	8	256	0	511	17	30.68
8	733	5	—	0	733	17	30.42
9	900	15	—	8	901	17	112.06
10	820	3	—	0	820	17	20.42
11	855	5	—	0	855	17	35.49
12	855	7	—	0	855	17	49.68
13	306	8	128	0	319	17	20.32
14	733	7	—	0	733	17	42.59
15	Locked						
16	612	4	0	0	663	17	20.32

OLIVETTI-/TRIUMPH-ADLER-BIOS Hard Drive Parameters							
Type	Cyl	Heads	WPC	Kb	LZ	Sectors	Meg
1	615	4	0	0	614	17	20.42
2	973	5	—	0	972	17	40.38
3	823	4	0	0	822	38	61.08
4	529	8	0	0	528	39	80.59
5	776	8	0	0	775	33	100.03
6	762	8	0	0	761	39	116.09
7	683	16	0	0	682	38	202.77
8	Locked						
9	Locked						
10	Locked						
11	Locked						
12	Locked						
13	Locked						
14	Locked						
15	Locked						
16	Locked						

AMI-BIOS Hard Drive Parameters							
Type	Cyl	Heads	WPC	Kb	LZ	Sectors	Meg
1	306	4	128	0	305	17	10.16
2	615	4	300	0	615	17	20.42
3	615	6	300	0	615	17	30.63
4	940	8	512	0	940	17	62.42
5	940	6	512	0	940	17	46.82
6	615	4	—	0	615	17	20.42
7	462	8	256	0	511	17	30.68
8	733	5	—	0	733	17	30.42
9	900	15	—	8	901	17	112.06
10	820	3	—	0	820	17	20.42
11	855	5	—	0	855	17	35.49
12	855	7	—	0	855	17	49.68
13	306	8	128	0	319	17	20.32

Type	Cyl	Heads	WPC	Kb	LZ	Sectors	Meg
14	733	7	—	0	733	17	42.59
15	Locked						
16	612	4	0	0	663	17	20.32
17	977	5	300	0	977	17	40.55
18	977	7	—	0	977	17	56.77
19	1024	7	512	0	1023	17	59.50
20	733	5	300	0	732	17	30.42
21	733	7	300	0	732	17	42.59
22	733	5	300	0	733	17	30.42
23	306	4	0	0	336	17	10.16
24	925	7	0	0	925	17	53.75
25	925	9	—	8	925	17	69.10
26	754	7	754	0	754	17	43.81
27	754	11	—	8	754	17	68.85
28	699	7	256	0	699	17	40.62
29	823	10	—	8	823	17	68.32
30	918	7	918	0	918	17	53.34
31	1024	11	—	8	1024	17	93.50
32	1024	15	—	8	1024	17	127.50
33	1024	5	1024	0	1024	17	42.50
34	612	2	128	0	612	17	10.16
35	1024	9	—	8	1024	17	76.50
36	1024	8	512	0	1024	17	68.00
37	615	8	128	0	615	17	40.84
38	987	3	987	0	987	17	24.58
39	987	7	987	0	987	17	57.35
40	820	6	820	0	820	17	40.84
41	977	5	977	0	977	17	40.55
42	981	5	981	0	981	17	40.72
43	830	7	512	0	830	17	48.23
44	830	10	—	8	830	17	68.90
45	917	15	—	8	918	17	114.18
46	1224	15	—	8	1223	17	152.40
47	User-defined						

AWARD-BIOS Hard Drive Parameters

Type	Cyl	Heads	WPC	Kb	LZ	Sectors	Meg
1	306	4	128	0	305	17	10.16
2	615	4	300	0	615	17	20.42
3	615	6	300	0	615	17	30.63
4	940	8	512	0	940	17	62.42
5	940	6	512	0	940	17	46.82
6	615	4	—	0	615	17	20.42
7	462	8	256	0	511	17	30.68
8	733	5	—	0	733	17	30.42
9	900	15	—	8	901	17	112.06
10	820	3	—	0	820	17	20.42
11	855	5	—	0	855	17	35.49
12	855	7	—	0	855	17	49.68
13	306	8	128	0	319	17	20.32
14	733	7	—	0	733	17	42.59
15	Locked						
16	612	4	0	0	663	17	20.32
17	977	5	300	0	977	17	40.55
18	977	7	—	0	977	17	56.77
19	1024	7	512	0	1023	17	59.50
20	733	5	300	0	732	17	30.42
21	733	7	300	0	732	17	42.59
22	733	5	300	0	733	17	30.42
23	306	4	0	0	336	17	10.16
24	977	5	—	0	976	17	40.55
25	1024	9	—	8	1279	17	76.50
26	1224	7	—	0	1223	17	71.12
27	1224	11	—	8	1223	17	111.76
28	1224	15	—	8	1223	17	152.40
29	1024	8	—	0	1023	17	68.00
30	1024	11	—	8	1023	17	93.50
31	918	11	—	8	1023	17	83.82
32	925	9	—	8	926	17	69.10
33	1024	10	—	8	1023	17	85.00
34	1024	12	—	8	1023	17	102.00
35	1024	13	—	8	1023	17	110.50

Type	Cyl	Heads	WPC	Kb	LZ	Sectors	Meg
36	1024	14	—	8	1023	17	119.00
37	1024	2	—	0	1023	17	17.00
38	1024	16	—	8	1023	17	136.00
39	918	15	—	8	1023	17	114.30
40	820	6	none	0	820	17	40.84

PHOENIX-BIOS Hard Drive Parameters

Type	Cyl	Heads	WPC	Kb	LZ	Sectors	Meg
1	306	4	128	0	305	17	10.16
2	615	4	300	0	615	17	20.42
3	615	6	300	0	615	17	30.63
4	940	8	512	0	940	17	62.42
5	940	6	512	0	940	17	46.82
6	615	4	—	0	615	17	20.42
7	462	8	256	0	511	17	30.68
8	733	5	—	0	733	17	30.42
9	900	15	—	8	901	17	112.06
10	820	3	—	0	820	17	20.42
11	855	5	—	0	855	17	35.49
12	855	7	—	0	855	17	49.68
13	306	8	128	0	319	17	20.32
14	733	7	—	0	733	17	42.00
15	Locked						
16	733	3	0	0	733	17	19.00
17	965	5	300	0	965	17	41.00
18	965	10	—	0	965	17	82.00
19	977	5	512	0	977	17	42.00
20	615	8	300	0	615	17	42.00
21	820	4	300	0	820	17	28.00
22	820	6	300	0	820	17	42.00
23	612	4	0	0	612	17	21.00
24	872	7	—	0	872	17	52.00
25	872	8	—	8	872	17	60.00

Type	Cyl	Heads	WPC	Kb	LZ	Sectors	Meg
26	Locked						
27	Locked						
28	Locked						
29	Locked						
30	Locked						
31	Locked						
32	Locked						
33	615	4	—	8	615	26	32.00
34	615	6	—	8	615	26	48.00
35	745	4	—	8	745	26	40.00
36	733	3	—	8	733	26	30.00
37	733	2	—	0	733	26	48.00
38	733	7	—	8	733	26	67.00
39	820	4	—	8	820	26	43.00
40	820	6	—	0	820	26	64.00
41	799	5	—	8	799	26	64.00
42	782	2	—	8	782	26	20.00
43	782	4	—	8	782	26	41.50
44	782	6	—	8	782	26	61.00
45	745	4	—	0	745	28	42.00
46	776	8	—	8	776	33	102.00
47	1148	4	none	8	1148	36	83.00

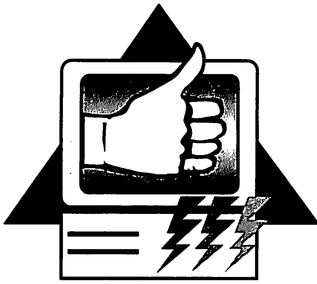
COMPAQ-BIOS Hard Drive Parameters

Type	Cyl	Heads	WPC	Kb	LZ	Sectors	Meg
1	306	4	128	0	305	17	10.16
2	615	4	128	0	638	17	20.42
3	615	6	128	0	615	17	30.63
4	1024	8	512	0	1023	17	68.00
5	805	6	—	0	805	17	40.09
6	697	5	128	0	696	17	28.93
7	462	8	256	0	511	17	30.68

Type	Cyl	Heads	WPC	Kb	LZ	Sectors	Meg
8	925	5	128	0	924	17	38.39
9	900	15	—	8	899	17	112.06
10	980	5	—	0	980	17	40.67
11	925	7	128	0	924	17	53.75
12	925	9	128	8	924	17	69.10
13	612	8	256	0	611	17	40.64
14	980	4	128	0	980	17	32.54
15	Locked						
16	612	4	0	0	612	17	20.32
17	980	5	128	0	980	17	40.67
18	966	5	128	0	966	17	40.09
19	754	11	—	8	753	17	68.85
20	733	5	256	0	732	17	30.42
21	733	7	256	0	732	17	42.59
22	524	4	—	0	524	40	40.94
23	924	8	—	0	924	17	61.36
24	966	14	—	8	966	17	112.26
25	966	16	—	8	966	17	128.30
26	1023	14	—	8	1023	17	118.88
27	832	6	—	0	832	33	80.44
28	872	14	—	8	872	52	308.03
29	1240	7	—	0	1240	34	143.90
30	615	4	128	0	615	25	30.03
31	615	8	128	0	615	25	60.06
32	905	9	128	8	905	25	99.43
33	832	8	—	0	832	33	107.25
34	966	7	—	0	966	34	111.74
35	966	8	—	0	966	34	127.70
36	966	9	—	8	966	34	143.67
37	966	5	—	0	966	34	79.81
38	611	16	—	8	611	63	298.27
39	1023	11	—	8	1023	33	177.68
40	1023	15	—	8	1023	34	255.25
41	1631	15	—	8	1631	52	618.18
42	1023	16	—	8	1023	63	501.49
43	805	4	—	0	805	26	40.88

Type	Cyl	Heads	WPC	Kb	LZ	Sectors	Meg
44	805	2	—	0	805	26	20.44
45	748	8	—	0	748	33	96.42
46	748	6	—	0	748	33	72.32
47	966	5	128	0	966	25	58.96

APPENDIX



B Hard Drive Parameters

The tables in Appendix B lists the hard drive parameter tables for several manufacturers. The columns in Appendix B have the following meanings:

Cyl	Cylinder	Sect	Sectors	WPC	Write precompensation
Cap	Capacity	AT	Access time	Proc	Procedure

Atasi Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
3046	7	645	35	323	80		RLL	
3051	7	704	35	352	88		RLL	
3085	8	1024	17	—	70		MFM	ST 506
3051+	7	733	35	368	91		RLL	

BASF Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
6185	6	440	17	220	22		MFM	ST 506
6186	4	440	17	220	15		MFM	ST 506
6187	2	440	17	220	7		MFM	ST 506
6188-R1	2	612	17		10		MFM	ST 506
6188-R3	4	612	17		20		MFM	ST 506

CDC Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
94155-120	8	960	17	—	64	28	MFM	ST 506
94155-129	8	925	26	—	97		RLL	ST 506
94155-129	8	922	26		155		RLL	ST 506
94155-135	9	960	26	—	110	28	RLL	ST 506
94155-135P	9	960	17	—	72	28	MFM	ST 506
94155-19	3	697	17	128	17		MFM	ST 506
94155-21	3	697	17	128	17	28	MFM	ST 506
94155-25	4	615	17	128	20		MFM	ST 506
94155-28	4	697	17	128	23		MFM	ST 506
94155-36	5	697	17	128	29	28	MFM	ST 506
94155-38	5	733	17	128	30	28	MFM	ST 506
94155-48	5	925	17	128	38	28	MFM	ST 506
94155-51	5	989	17		43		MFM	ST 506
94155-57	6	925	17	128	46	28	MFM	ST 506
94155-67	7	925	17	128	54	28	MFM	ST 506
94155-77	8	925	17	128	61		MFM	ST 506
94155-85	8	1024	17		68	28	MFM	ST 506
94155-85P	8	1024	17		68	28	MFM	ST 506
94155-86	9	925	17	128	69	28	MFM	ST 506
94155-96	9	1024	17		77	28	MFM	ST 506
94155-96P	9	1024	17		77	28	MFM	ST 506
94166-101	5	969	34	—	84		RLL	ESDI
94166-141	7	969	34	—	117		RLL	ESDI
94166-182	9	969	35	—	155		RLL	ESDI
94186-265	9	1412	34	—	220			ESDI
94186-324	11	1412	34	—	269		RLL	ESDI
94186-383	13	1412	34	—	318		RLL	ESDI
94186-383H	15	1224	34	—	318		RLL	ESDI
94186-442	15	1412	34	—	367		RLL	ESDI
94204-65	8	941	17		62	28	MFM	ST 506
94204-71	8	1024	17		68	28	MFM	ST 506
94205-51	5	989	17	128	41	32	MFM	ST 506
94205-77	5	989	26	—	63	28	RLL	ST 506
94295-51	5	989	17	990	41	28	MFM	ST 506
94335-100	9	1072	17	—	80	15	MFM	ST 506

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
94335-150	9	1072	26	—	123	25	RLL	ST 506
94335-55	5	1072	17	—	45	25	MFM	St 506
94351-128	7	1068	36		131		RLL	SCSI
94351-160	9	1068	36		169		RLL	SCSI
94351-200	9	1068	36		169		RLL	SCSI
94351-200S	9	1068	36		169		RLL	ST 506
94356-200	9	1272	34	—	190	18	RLL	ESDI
BJ7D4A	4	671	17		22		MFM	ST 506
BJ7D5A	5	671	17		28		MFM	ST 506

CMI Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
CM 3206	4	306	17		10		MFM	ST 506
CM 3426	4	612	17	256	20		MFM	ST 506
CM 5205	2	256	17	128	4		MFM	ST 506
CM 5206	2	306	17	128	5		MFM	ST 506
CM 5410	4	256	17	128	8		MFM	ST 506
CM 5412	4	306	17	128	10		MFM	ST 506
CM 5616	6	256	17	128	13		MFM	ST 506
CM 5619	6	306	17	128	15		MFM	ST 506
CM 5826	8	306	17	128	20		MFM	ST 506
CM 6213	2	640	17	256	10		MFM	ST 506
CM 6426	4	615	17	256	20		MFM	ST 506
CM 6626	4	640	17	256	21		MFM	ST 506
CM 6640	6	640	17	256	32		MFM	ST 506
CM 7660	6	960	17	512	48		MFM	ST 506
CM 7880	8	960	17	512	64		MFM	ST 506

Conner Hard Drive Parameters								
Model	**Heads**	**Cyl**	**Sect**	**WPC**	**Cap**	**AT**	**Proc**	**Port**
CP-2024	2	653	32	21			IDE	
CP-3000	5	980	17	42	28		IDE	
CP-30100				120	19		SCSI	
CP-30104	14	997	17	120	19		IDE	
CP-30204				212	16		IDE	
CP-3022	2	636	27	20	26	RLL	IDE	
CP-3024	2	636	33	21			IDE	
CP-3040	2	1047		41	25	RLL	SCSI	
CP-3044	2	1047	40	41	25	RLL		
CP-3100	8	776	33	104	29	RLL	SCSI	
CP-3102A	8	776	33	104	26	RLL	IDE	
CP-3102B	8	776	33	104	26	RLL	IDE	
CP-3104	8	776	33	105	25		IDE	
CP-3184	6	832	33	82			IDE	
CP-3200	8	1348	39	210	19	RLL	SCSI	
CP-3200F				212	16		SCSI	
CP-3204	16	683	38	210			IDE	
CP-3204F	16	683	38	210	16		IDE	
CP-321	4	612	17	21	19	MFM	IDE	
CP-340	4	788	26	40	29	RLL	SCSI	
CP-342	4	805	26	42	26	RLL	IDE	
CP-344	4	805	26	42	26	RLL	IDE	
CP-4024	2	627	34	21			IDE	
CP-4044	2	1105	34	42			IDE	
RCP-3200				212	16	RLL	SCSI	

CORE Hard Drive Parameters								
Model	**Heads**	**Cyl**	**Sect**	**WPC**	**Cap**	**AT**	**Proc**	**Port**
AT 30	5	733	17		30	26	MFM	ST 506
AT 32	5	733	17		30	21	MFM	ST 506
AT 40	5	924	17		38	26	MFM	ST 506
AT 63	5	988	26		63	26	MFM	ST 506
AT 72	9	924	17		70	26	MFM	ST 506

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
HC 100	6	969	35		100	9	MFM	ESDI
HC 150	9	968	35		154	16	RLL	ESDI
HC 310	12	1582	32		310	16	MFM	ESDI
HC 380	15	1412	35		377	16	MFM	ESDI
HC 40	4	564	35		39	10	RLL	ESDI
HC 650	16	1938	35		647	16	MFM	ESDI
HC 90	5	969	35		83	16	RLL	ESDI
OP 70	9	918	17		70	26	MFM	ST 506
OPTIMA 30	5	733	17		30	21	MFM	ST 506
OPTIMA 40	5	963	17		40	26	MFM	ST 506
OPTIMA 70	9	918	17		70	26	MFM	ST 506

Data General Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
MOD 6526	8	1024	17		70	28	MFM	ST 506
MOD 6535	15	1224	35		320	18		ESDI
MOD 6537	15	1224	17		157	30	MFM	ST 506

Fuji Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
FK301	4	306	17	128	10		MFM	ST 506
FK302-13	2	612	17	307	10		MFM	ST 506
FK302-26	4	612	17	307	20		MFM	ST 506
FK302-39	6	612	17	307	30		MFM	ST 506
FK303-52	8	615	17	616	41	50	MFM	ST 506
FK305-26	4	615	17	616	20	80	MFM	ST 506
FK305-39	6	615	17	616	31	80	MFM	ST 506
FK305-39R	4	615	26		31	50	RLL	ST 506
FK305-58R	6	615	26		47	50	RLL	ST 506
FK308S-39R	4	615	17		20	50	MFM	SCSI
FK308S-58R	6	615	17		30	50	MFM	SCSI

Fuji Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
FK309-26	4	615	17	300	20	80	MFM	ST 506
FK309-39	4	615	26		31	80	RLL	ST 506
FK309-39R	4	615	26		31	80	RLL	ST 506
FK309-58	6	615	26		47		RLL	ST 506

Fujitsu Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
2230 AS	2	320	17		5		MFM	ST 506
2233 AS	4	320	17		10		MFM	ST 506
2234 AS	6	320	17		16		MFM	ST 506
2235 AS	8	320	17		21		MFM	ST 506
2241 AS	4	754	17		25		MFM	ST 506
2244E	5	823	35		70	25	RLL	ESDI
2244SA	5	823	35		70	25	RLL	SCSI
2245E	7	823	35		98	25	RLL	ESDI
M 2225D	4	615	26		31	35	RLL	ST 506
M 2225DR	4	615	26		31	35	RLL	ST 506
M 2226D2	6	615	17		31	35	MFM	ST 506
M 2226DR	6	615	26		47	35	RLL	ST 506
M 2227D2	8	615	17		41	35	MFM	ST 506
M 2227DR	8	615	26		63	35	RLL	ST 506
M 2230AS	2	306	17		5		MFM	ST 506
M 2230AT	2	306	17		5		MFM	ST 506
M 2231	2	306	17		5		MFM	ST 506
M 2233AS	4	306	17		10		MFM	ST 506
M 2233AT	4	306	17		10		MFM	ST 506
M 2234AS	6	306	17		15		MFM	ST 506
M 2235AS	8	306	17		20		MFM	ST 506
M 2241AS	4	754	17	375	25		MFM	ST 506
M 2242	7	754	17	375	44		MFM	ST 506
M 2243AS	11	754	17	375	69		MFM	ST 506
M 2243R	7	1186	26		105	25	RLL	ST 506

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
M 2243T	7	1186	17		69	25	RLL	ST 506
M 2245SA	7	823	35		98	25	RLL	SCSI
M 2246E	10	823	35		141	25	RLL	ESDI
M 2246SA	10	823	35		141	25	RLL	SCSI
M 2247E	7	1243	35		149	25	RLL	ESDI
M 2249E	15	1243			302	18	RLL	ESDI
M 2249SA	15	1243			300	18	RLL	SCSI
M 2261E	8	1658	53		357	16		ESDI
M 2261SA	8	1658	53		357	16		SCSI
M 2263E	15	1658	53		670	16	RLL	ESDI
M 2263SA	15	1658	53		670	16	RLL	ESDI
M 2266SA	15	1658	85		1080	30		SCSI
M 2611S	2	1334			43	25	RLL	SCSI
M 2611SA	2	1334	34		45	25		SCSI
M 2611T	4	667	33		45	25		IDE
M 2612S	4	1334			89	20	RLL	SCSI
M 2613ESA	6	1334	34		135	20		SCSI
M 2613ET	12	667	33		135	20		IDE
M 2613S	6	1334			134	20	RLL	SCSI
M 2614ESA	8	1334	34		182	20		SCSI
M 2614ET	16	667	33		180	20		IDE
M 2614S	8	1334			177	20	RLL	SCSI
M 2616ESA	4	1542	34		104	20		SCSI
M 2616ET	8	771	33		104	20		IDE
M 2622SA					330	12		SCSI
M 2622T					326	12		IDE
M 2623SA					420	12		IDE
M 2623T					420	12		IDE
M 2624SA					520	12		IDE
M 2624T					513	12		IDE
M 2652SA					1700	11		SCSI

Hitachi Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
DK 301-1	4	306	17		10	85	MFM	ST 506

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
DK 301-2	6	306	17		15	85	MFM	ST 506
DK 511-3	5	699	17	300	29	30	MFM	ST 506
DK 511-5	7	699	17	300	41	30	MFM	ST 506
DK 511-8	10	823	17	400	68	23	MFM	ST 506
DK 512-12	7	823	17		48	23	MFM	ESDI
DK 512-17	10	823	17		68	23	MFM	ESDI
DK 512-8	5	823	17		34	23	MFM	ESDI
DK 512C-12	7	823	35		99	23	RLL	SCSI
DK 512C-17	10	819	35		140	23	RLL	SCSI
DK 512C-8	5	823	35		70	23	RLL	SCSI
DK 521-5	6	823	17	400	41	25	MFM	ST 506
DK 522-10	6	823	36		87	25	RLL	ESDI
DK 522C-10	6	819	35		84	25	RLL	SCSI

Hewlett-Packard Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
HP 97544E	8	1457			340	17		ESDI
HP 97544T	8	1447	56		331	17		SCSI
HP 97548E	16	1457	57		680	17		ESDI
HP 97548T	16	1447	56		663	17		SCSI
HP 97549T/P	16	1918	64		1000	18		SCSI
HP 97556E	11	1680	72		681	15		ESDI
HP 97556T	11	1670	72		673	15		SCSI
HP 97558E	15	1961	72		1080	15		ESDI
HP 97558T/P	15	1952	72		1000	15		SCSI
HP 97560E	19	1961	72		1370	15		ESDI
HP 97560T/P	19	1952	72		1300	14		SCSI
HP C2233A	5	1260	72		234	13		IDE
HP C2233S	5				234	13		SCSI
HP C2234A	7	1260	72		328	13		IDE
HP C2234S	7				328	13		SCSI
HP C2235A	9	1260	72		422	13		IDE
HP C2235S	9				422	13		SCSI

Imprimis Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
94166	7	969	34		113		RLL	
9415-536	5	697	17		29		MFM	ST 506
9415-538	5	733	17		30		MFM	ST 506
94155-120	8	960	26		97		RLL	ST 506
94155-135	9	960	26		110		RLL	
94155-135P	9	960	26		110		RLL	
94155-48	5	925	17		39		MFM	
94155-56	9	925	17		69		MFM	
94155-57	6	925	17		46		MFM	
94155-67	7	925	17		54		MFM	
94155-77	8	925	17		61		MFM	
94155-85	8	1024	17		68		MFM	
94155-85P	8	1024	17		68		MFM	
94155-86	9	925	17		69		MFM	
94155-96	9	1024	17		77		MFM	
94155-96P	9	1024	17		77		MFM	
94156-48	5	925	17		38		MFM	
94156-67	7	925	17		54		MFM	
94156-86	9	925	17		69		MFM	
94166-101	5	969	34		80		RLL	
94166-182	9	969	34		145		RLL	
94204-65	8	941	17		62		MFM	
94204-71	8	1024	17		68		MFM	
94205-51	5	989	17		41		MFM	
94205-77	5	989	26		63		RLL	
94216-106	5	1024	34		85		RLL	
94354-135	9	1072	26		122		RLL	
94354-160	9	1072	29		137		RLL	
94354-172	9	1072	36		170		RLL	
94354-200	9	1072	36		170		RLL	
94355-100	9	1072	17		80		MFM	
94355-150	9	1072	26		122		RLL	
94356-11	5	1072	36		94		RLL	
94356-155	7	1072	36		132		RLL	
94356-200	9	1072	36		170		RLL	

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
Wren II 85 P FH	9	1024	17		69	28	MFM	ST 506
Wren II FH	9	924	17		72	28	MFM	ST 506
Wren II HH	5	989	17		40	28	MFM	ST 506
Wren II HH AT	5	1032			71	28	RLL	
Wren III FH	9	969			153	17	RLL	ESDI
Wren III FH	9	969			151	17	RLL	SCSI
Wren III HH	5	1024			90		RLL	SCSI
Wren III HH	5	1024			90		RLL	ESDI
Wren IV FH	9	1549			340	17		SCSI
Wren V 383 H	15	1224			338	15	RLL	ESDI
Wren V FH	15	1546			635	17		SCSI
Wren V HH	5	1544			188	18		SCSI
Wren VI FH	15	1632			700	17	RLL	ESDI
Wren VI HH	7	1747			335	16	RLL	ESDI
Wren VI HH	7	1747			333	16	RLL	SCSI
Wren VII FH	15	1937			1010	17		SCSI

Kontron Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
SQ 555	2	1278			42	25	RLL	SCSI

Kyocera Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
KC20A	4	615	17	300	21		MFM	ST 506
KC20B	4	615	17	300	21		MFM	ST 506
KC30A	4	615	26	—	31		RLL	ST 506
KC30B	4	615	26	—	31		RLL	ST 506
KC80C	8	788	27		86		RLL	SCSI

Lanstor Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
LAN-64	8	1024	17	—	70		MFM	ST 506
LAN-115	15	918	17	—	117		MFM	ST 506
LAN-140	8	1024	34		140			
LAN-180	8	1024	26	—	107		RLL	ST 506

Lapine Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
3062	4	306	17	0	10		MFM	ST 506
3512	4	306	17	0	10		MFM	ST 506
3522	4	306	17	0	10		MFM	ST 506
LT 200	4	615	17	0	20	60	MFM	ST 506
LT 2000	4	615	17	0	20	61	MFM	ST 506
T-10	2	615	17		10		MFM	ST 506
T-20	4	615	17	0	20	61	MFM	ST 506
T-30	4	615	27		32	65	RLL	ST 506
T-300	4	615	27		32	65	RLL	ST 506

Maxtor Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
4230E	9	1224	36		203	16		ESDI
7040A	5	980	17		40	19		IDE
7060AT	7	1024	17		62	15		IDE
7080A	10	980	17		80	19		IDE
7120AT	14	1024	17		125	15		IDE
7120S	4	1498	39		125	15		SCSI
8051A	5	977	17		40	28		IDE
8760E	15	1632	54		676	16	RLL	ESDI
8760S	15	1632	54		676	16	RLL	SCSI
AT-120	16	918	17		120	26	MFM	ST 506
AT-160	16	1224	17		160	28	MFM	ST 506

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
AT-70	9	1024	17		70	27	MFM	ST 506
LXT-213A	16	683	38		213	15		IDE
LXT-213S	15	918	30		213	15		SCSI
LXT-340AT	16	654	63		340	13		IDE
LXT-340S	15	1560	24		340	13		SCSI
LXT-535S	11	1560	61		535	13	RLL	SCSI
MPO-1,2S	19	1216	85		1000	13		SCSI FH
MPO-1,7S					1500	13		SCSI
XT-1065	7	918	17	—	55	28	MFM	ST 506
XT-1085	8	1024	17	—	70	28	MFM	ST 506
XT-1105	11	918	17	—	87	27	MFM	ST 506
XT-1120	8	1024	26	—	104	27	RLL	ST 506
XT-1120R	8	1024	26	—	104	27	RLL	ST 506
XT-1140	15	918	17	—	117	27	MFM	ST 506
XT-1240	15	1024	26	—	195	27	RLL	ST 506
XT-1240R	15	1024	26	—	195	27	RLL	ST 506
XT-2085	7	1224	17	—	73	30	MFM	ST 506
XT-2140	11	1224	17	—	112	30	MFM	ST 506
XT-2190	15	1224	17	—	157	29	MFM	ST 506
XT-4170E	7	1224	36	—	157	14	RLL	ESDI
XT-4170S	7	1224	36	—	157	14	RLL	SCSI
XT-4280S	11	1224	34	—	233		RLL	SCSI
XT-4380	15	1224	17	—	142	16	MFM	ST 506
XT-4380E	15	1224	35	—	338	16	RLL	ESDI FH
XT-4830S	15	1224	36	—	338	16	RLL	SCSI FH
XT-8380E	8	1632	54	—	344	14	RLL	ESDI
XT-8380S	8	1632	48	—	320	16	RLL	SCSI FH
XT-8760	15	1632	54	—	646	16	RLL	IDE
XT-8760S	15	1632	48	—	601	16	RLL	SCSI

Memorex Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
321	2	320	17	128	5		MFM	ST 506
322	4	320	17	128	10		MFM	ST 506
323	6	320	17	128	16		MFM	ST 506
324	8	320	17	128	21		MFM	ST 506
450	2	612	17	350	10		MFM	ST 506
512	3	961	17	480	24		MFM	ST 506
513	5	961	17	480	40		MFM	ST 506
514	6	961	17	480	48		MFM	ST 506

Micropolis Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
1302	3	830	17	400	21		MFM	ST 506
1303	5	830	17	400	34		MFM	ST 506
1304	6	830	17	400	41		MFM	ST 506
1323	4	1024	17	—	34	28	MFM	ST 506
1324	6	1024	17	—	51	28	MFM	ST 506
1325	8	1024	17	—	70	28	MFM	ST 506
1333	4	1024	17	—	34	28	MFM	ST 506
1334	6	1024	17	—	51	30	MFM	ST 506
1335	8	1024	17	—	68	30	MFM	ST 506
1352	2	1024	36		36	23	RLL	ESDI
1353	4	1024	36		72	23	RLL	ESDI
1354	6	1024	36		108	23	RLL	ESDI
1355	8	1024	36		144	23	RLL	ESDI
1373	4	1024	36		72	23	RLL	SCSI
1374	6	1024	36		108	23	RLL	SCSI
1375	8	1024	36		144	23	RLL	SCSI
1551	7	1024	17	—	60	30	MFM	ST 506
1554	11	1224	17	—	122	30	MFM	ST 506
1555	12	1224	17	—	122	30	MFM	ST 506
1556	13	1224	17	—	132	30	MFM	ST 506
1557	14	1224	17	—	142	30	MFM	ST 506

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
1558	15	1224	17	—	152	30	MFM	ST 506
1624					667	15		SCSI
1324A	7	1024	17		61		MFM	ST 506
1333A	5	1024	17		42	30	MFM	ST 506
1352A	3	1024	36		54	23	RLL	ESDI
1353A	5	1024	36		90	23	RLL	ESDI
1354A	7	1024	36		126	23	RLL	ESDI
1373A	5	1024	36		90	23	RLL	SCSI
1374A	7	1024	36		126	23	RLL	SCSI
1518-15					1340	15		ESDI
1538-15					1050	15		ESDI
1548-15					1750	14		SCSI
1556-11	11	1224	35		238			
1557-12	12	1224	35		258			
1557-13	13	1224	35		280			
1558-15	15	1224	36		337	18	RLL	ESDI
1568-15					676	14		ESDI
1578-15	15	1220	35		325	18	RLL	SCSI
1580-15					668	16		SCSI
1598-15					1030	14		SCSI
1653-4	4	1249	36		88	16	RLL	ESDI
1653-5	5	1249	36		110	16	RLL	ESDI
1654-6	6	1249	36		132	16	RLL	ESDI
1654-7	7	1249	36		154	16	RLL	ESDI
1664-7					345	14	RLL	SCSI
1674-7					158	16		SCSI
1683-4	4	1776	54		187	14	RLL	SCSI
1684-7					340	14		SCSI
1773-5	5	1140	48		134	15	RLL	SCSI
1774-6	6	1140	48		160	15	RLL	SCSI
1774-7	7	1140	48		187	15	RLL	SCSI

Microscience Hard Drive Parameters								
Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
4050	6	1024	17		51	18	MFM	ST 506
4060	6	1024	26		67	18	RLL	ST 506
4090	8	1024			93	18	RLL	ST 506
5100	7	855	36		105	18	RLL	ESDI
6100	7	855	36		105	18	RLL	SCSI
7040	3	855	36		45	18	RLL	ESDI
7100	7	855	36		105	18	RLL	ESDI
HH-1050	5	1024	17	—	42	28	MFM	ST 506
HH-1060	5	1024	26		65	28	RLL	ST 506
HH-1075	7	1024	17		60	28	MFM	ST 506
HH-1090	7	1314	17		76	28	MFM	ST 506
HH-1095	7	1024	26		91	28	RLL	ST 506
HH-1120	7	1314	26		117	28	RLL	ST 506
HH-2120	7	1024	33		115	28	RLL	ST 506
HH-2160 F	8	1276			160	18	RLL	ESDI
HH-312	4	306	17	—	10		MFM	ST 506
HH-315	2	612	17	—	10		MFM	ST 506
HH-3160 F	8	1314			190	18	RLL	SCSI
HH-325	4	615	17	—	20	80	MFM	ST 506
HH-330	4	612	26		31		RLL	ST 506
HH-4050	5	1024	17		42	18	MFM	ST 506
HH-4060	5	1024	17		42	18	MFM	ST 506
HH-4070	7	1024	17		60	18	MFM	ST 506
HH-4090	7	1024	17		60	18	MFM	ST 506
HH-612	4	306	17	—	10		MFM	ST 506
HH-625	4	612	17		20		MFM	ST 506
HH-7100	7	960	35		110	18	RLL	IDE
HH-712	2	612	17	—	10	105	MFM	ST 506
HH-725	4	612	17	—	20	105	MFM	ST 506
HH-738	4	612	26		31	105	RLL	ST 506
HH-8040	2	1024	40		40	19		IDE
HH-825	4	615	17		20	65	MFM	ST 506
HH-830	4	615	26		31	65	RLL	ST 506

Miniscribe Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
3012	2	615	17	300	10		MFM	ST 506
3053	5	1024	17		42		MFM	ST 506
3085	7	1170	17	512	62		MFM	ESDI
3138	4	615	25		31		RLL	ST 506
3145	4	615	17	300	20		MFM	ST 506
3425	4	615	17	300	20		MFM	ST 506
3438	4	613	26	128	31	85	RLL	ST 506
3650	6	809	17	—	40	61	MFM	ST 506
3675	6	809	17	—	40	61	MFM	ST 506
6032	3	1024	17	512	25	28	MFM	ST 506
6053	5	1024	17	512	42	28	MFM	ST 506
6074	7	1024	17	512	60	28	MFM	ST 506
6085	8	1024	17	512	68	28	MFM	ST 506
6128	8	1024	26	512	104	28	RLL	ST 506
8138	4	615	26		32		RLL	ST 506
8425	4	615	17	128	20	68	MFM	ST 506
8438	4	615	26	128	31	61	RLL	ST 506
8450	4	805	26		42	68	RLL	ST 506
3130E	5	1250	35	—	110			ESDI
3180E	7	1254	35	—	150	17	RLL	ESDI
3180S	7	1250			155	17	RLL	ESDI
8051A	4	745	26	300	28	42	RLL	ST 506
8051S	4	615	17	300	20		MFM	ST 506
8125S	4	612	17		20		MFM	SCSI
8138F	4	615	26		32		RLL	ST 506
8425F	4	615	17	—	20	68	MFM	ST 506
8425S	4	612	17		21		MFM	SCSI
8438F	4	615	26	128	31	61	RLL	ST 506
9230E	9	1224	35	—	188	17	RLL	ESDI
9380E	15	1224	35	—	330	16	RLL	ESDI
9380S	7	1255			345	16	RLL	SCSI
9780E	15	1224			650	17	RLL	SCSI
9780S	15	1661			666	17	RLL	ESDI

Mitsubishi Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
MR 335-OOM	7	743	17		41	20	MFM	ST 506
MR 522	4	612	17	300	20		MFM	ST 506
MR 533	3	977	17	X	25		MFM	ST 506
MR 535	5	971	17	X	41	28	MFM	ST 506
MR 535-OOM	5	977	26		63	28	RLL	ST 506

NEC Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
D 3142	8	642	17	128	43	28	MFM	ST 506
D 3146H	8	615	17		42	35	MFM	ST 506
D 3155	4	1251			105	25	RLL	IDE
D 3661	7	915	26		117	23	RLL	ESDI
D 3735	2	1074			45	25	RLL	IDE
D 3755	8	625	41		102			IDE
D 3756	8	625	41		102			IDE
D 3756	4	1251			105	19	RLL	IDE
D 3835	2	1074			45	25	RLL	SCSI
D 3841	8	642	17		42	28	MFM	ST 506
D 3855	4	1251			105	25	RLL	SCSI
D 3856	4	1251			105	19	RLL	SCSI
D 3861	7	914	36		117	23	RLL	SCSI
D 5124	4	306	17	—	10	85	MFM	ST 506
D 5126	4	612	17	128	21	85	MFM	ST 506
D 5126H	4	612	17	300	21	85	MFM	ST 506
D 5127H	4	615	26	—	32		RLL	ST 506
D 5128	4	612	17	300	21	80	MFM	ST 506
D 5146	8	615	17	128	42	85	MFM	ST 506
D 5146H	8	615	17	128	42	85	MFM	ST 506
D 5147H	8	615	26	—	63		RLL	ST 506
D 5452	10	823	17		71		MFM	ST 506
D 5652	10	823	36		134	21	RLL	ESDI

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
D 5655	8	1224	36		140	18	RLL	ESDI
D 5662	16	1224	36		300	18	RLL	ESDI
D 5852					147	21		SCSI
D 5862	15	1221	36		325	18	RLL	SCSI
HD135 AT					114	20	RLL	IDE
HD180					179	18	RLL	ESDI
HD385 S					384	18	RLL	SCSI
HD760					758	18	RLL	ESDI

Newburry Data Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
NDR320	4	615	17		20		MFM	ST 506
NDR340	8	615	17		40		MFM	ST 506
NDR1085	8	1024	17	—	73		MFM	ST 506
NDR1105	11	918	17	—	90		MFM	ST 506
NDR1140	15	918	17	—	121		MFM	ST 506
NDR2190	15	1024	17	—	140		MFM	ST 506

Priam Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
514	11	1224	17	—	115		MFM	ST 506
519	15	1224	17	—	157		MFM	ST 506
ID 160-SC	7	1218			160	18	RLL	SCSI
ID 250-SC	11	1218			250	18	RLL	SCSI
ID 330-EC	15	1218			330	18	RLL	ESDI
V 130	3	987	26	—	38		RLL	ST 506
V 150	5	987	17	—	41		MFM	ST 506
V 170	7	987	17	—	57		MFM	ST 506
V 185	7	1166	17	—	68		MFM	ST 506

Procom Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
PIRA 40	4	745			43	28	RLL	
PIRA 100	8	776			100	25	RLL	

PTI Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
PT225	4	615	17	300	21		MFM	ST 506
PT234	4	820	17	544	28		MFM	ST 506
PT238R	4	615	26	300	32		RLL	ST 506
PT251R	4	820	26	544	42		RLL	ST 506
PT338	6	615	17	300	32		MFM	ST 506
PT351	6	820	17	544	42		MFM	ST 506
PT357R	6	615	26	300	49		RLL	ST 506
PT376R	6	820	26	544	65		RLL	ST 506
PT4102	8	820	26	544	85		RLL	ST 506
PT468	8	820	17	544	57		MFM	ST 506

Quantum Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
120AT	9	814	32		120	15		IDE
170AT	10	968	34		168	15		IDE
210AT	13	873	36		210	15		IDE
330AT	12	1520	51		331	14		IDE
40AT	5	965	17		42	19		IDE
425AT	16	1520	51		426	14		IDE
80AT	10	965	17		84	19		IDE
LPS 105AT	16	755	17	755	100	17		IDE
LPS 52AT	8	751	17	751	50	17		IDE
ProDrive 80	6	834	34		80	19	RLL	IDE
Q 520	4	512	17	256	17	17	MFM	ST 506

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
Q 530	6	512	17	256	25	17	MFM	ST 506
Q 540	8	512	17	256	34	17	MFM	ST 506

Rodime Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
RO 202E	4	640	17	—	21	55	MFM	ST 506
RO 203	6	321	17	0	16	85	MFM	ST 506
RO 203E	6	640	17	0	32	55	MFM	ST 506
RO 204	8	321	17	0	21	85	MFM	ST 506
RO 204E	8	640	17	0	42	55	MFM	ST 506
RO 3/287	7	868			105	18	RLL	SCSI
RO 3055	6	872	17	650	44	28	MFM	ST 506
RO 3057S	5	680	26		44		RLL	SCSI
RO 3065	7	872	17		51	28	MFM	ST 506
RO 3075R	6	750	26	650	57		RLL	ST 506
RO 30858	7	750	26		68	28	RLL	SCSI
RO 3085R	7	750	26	650	67		RLL	ST 506
RO 3085S	7	750	26		68		RLL	SCSI
RO 3128 A	7	868			105	18	RLL	IDE
RO 3130T	7	1053			103		RLL	SCSI
RO 5090	7	1224	17	—	71	28	MFM	ST 506
RO 5125E	5	1224	36	—	112		RLL	ESDI
RO 5125S	5	1219			100		RLL	SCSI
RO 5130R	7	1224	26	—	113		RLL	ST 506
RO 5175E	5	1224	36		112		RLL	ESDI
RO 5180E	7	1224	36	—	155		RLL	ESDI
RO 5180S	7	1219			142		RLL	SCSI
RO 5180T	7	1219			142		RLL	SCSI
RO 703E	6	640	17		33		MFM	ST 506

Seagate Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
ST 1057A	6	1024	17	—	52	18	ZBR	IDE
ST 1090A	16	335	29	—	79	17	RLL	IDE
ST 1096N	9	1024	17		80	28	MFM	SCSI
ST 1102A	10	1024	17		89	19	ZBR	IDE
ST 1111A	10	402	48	—	98	15	RLL	IDE
ST 1111E					95	15	RLL	SCSI
ST 1126A	16	469	29	—	110	17	RLL	IDE
ST 1133A	8	477	60	—	117	15	RLL	IDE
ST 1144A	14	1024	17		124	19	ZBR	IDE
ST 1156A	9	536	56	—	138	15	RLL	IDE
ST 1162A	9	1024	31		143	15		IDE
ST 1162A	16	603	29	—	143	15	RLL	IDE
ST 1186A	9	636	56	—	163	15	RLL	IDE
ST 1186N					160	15	RLL	SCSI
ST 1201A	9	1013	38		177	15	RLL	IDE
ST 1201E					178	15	RLL	ESDI
ST 1201N					170	15	RLL	SCSI
ST 1239A	14	818	36		211	15	RLL	IDE
ST 1239N	9	1302	35		210	15	RLL	SCSI
ST 125	4	615	17	300	20	40	MFM	ST 506
ST 125A	4	614	17	300	20	28	RLL	IDE
ST 138	6	615	17	—	31	40	MFM	ST 506
ST 138A	6	615	17	—	31	28	RLL	IDE
ST 138R	4	615	26	—	31	40	RLL	ST 506
ST 1400A					330	14	ZBR	IDE
ST 1400N					330	14	ZBR	SCSI
ST 1401A					340	12	ZBR	IDE
ST 1401N					340	12	ZBR	SCSI
ST 1480A	15	985	62	—	420	14	ZBR	IDE
ST 1480N					426	14	ZBR	SCSI
ST 1481N					426	14	ZBR	SCSI
ST 151	5	977	17	—	42	28	MFM	ST 506
ST 157A	7	733	17		44	28	RLL	IDE

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
ST 157N	6	615	26	—	47		RLL	SCSI
ST 157R	6	615	26	—	47	40	RLL	ST 506
ST 177N	5	921			60	24	RLL	SCSI
ST 213	2	615	17	300	10	65	MFM	ST 506
ST 2182E					160	16	RLL	ESDI
ST 225	4	615	17	300	20	65	MFM	ST 506
ST 2274A	10	873	54	—	240	16	RLL	IDE
ST 227R	6	820	26	—	65	28	RLL	ST 506
ST 2383A	14	874	54		338	16	RLL	IDE
ST 2383E	7	1747	54		338	16	RLL	ESDI
ST 238R	4	615	26	300	30	65	RLL	ST 506
ST 2502N					442	16	ZBR	SCSI
ST 250R	4	667	31	—	40	70	RLL	
ST 251	6	820	17	—	41	40	MFM	ST 506
ST 251R	6	820	26	—	62	40	RLL	ST 506
ST 274A	8	941	17	—	64	28	RLL	IDE
ST 277N	6	818	26	—	62	28	RLL	SCSI
ST 277R	6	820	26	—	62	40	MFM	ST 506
ST 280A	8	1024	17	—	70	28	RLL	IDE
ST 296N	6	820			85	28	MFM	SCSI
ST 3096A	10	1024	17	—	88	15	ZBR	IDE
ST 3120A	12	1024	17	—	105	16	ZBR	IDE
ST 3144A	15	1001	17	—	124	16	ZBR	IDE
ST 325A	4	615	17	300	21	28	RLL	IDE
ST 3283A					245	12	RLL	IDE
ST 3283N					245	12	RLL	SCSI
ST 3500N					426	10	ZBR	SCSI
ST 351A	6	820	17		42	28	RLL	IDE
ST 3600 A					525	11	ZBR	IDE
ST 4026	4	615	17	300	20		MFM	ST 506
ST 4038	5	733	17	300	30	40	MFM	ST 506
ST 4038M	5	733	17	—	30	40	MFM	ST 506
ST 4051	5	977	17	—	41	40	MFM	ST 506
ST 4053	5	1024	17	—	42	28	MFM	ST 506
ST 4077R	5	1024	26	—	65	28	RLL	ST 506
ST 4096	9	1024	17	—	77	28	MFM	ST 506

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
ST 412	4	306	17	128	10		MFM	ST 506
ST 41200N	15	1931	68		1000	16	ZBR	SCSI
ST 4144R	9	1024	26	—	117	28	RLL	SCSI
ST 41601N					1340	11	ZBR	SCSI
ST 41650N	15	2107	98		1600	15		SCSI
ST 43400N					1900	13	ZBR	SCSI
ST 43401N					2800	11	ZBR	SCSI
ST 4385N	16	1024	40		338	11	ZBR	SCSI
ST 4442E					380	16	RLL	ESDI
ST 4702N					613	17	RLL	SCSI
ST 4766E	15	1632	54		663	15	RLL	ESDI
ST 4766N	15	1632	54		663	15		SCSI
ST 4767E					676	12	RLL	ESDI
ST 4767N	15	1356	64		701	11		SCSI
ST 4769E					691	13	RLL	ESDI
ST 9096A					80	16	RLL	IDE
ST 9096N					80	16	RLL	SCSI
ST 9144A	14	1024	17		120	16	RLL	IDE
ST 9144N					120	16	RLL	SCSI

Storage Dimensions Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
175i					175	18		SCSI
345i					345	14		SCSI
45i					45	29		SCSI
650i					650	17		SCSI
90i					90	29		SCSI
AT-100R	8	1024	26		107		RLL	ST 506
AT-120	16	918	17		120	26	MFM	ST 506
AT-133	15	1024	17		130		MFM	ST 506
AT-140	8	1024	34		138		RLL	
AT-155E	7	969	36		150			SCSI
AT-160	16	1224	17		160	28	MFM	ST 506

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
AT-160	15	1224	17		155		MFM	ST 506
AT-200R	15	1024	26		200		RLL	ST 506
AT-320	15	1224	35		320			
AT-335E	15	1224	36		330			ESDI
AT-40	5	1024	17		41		MFM	ST 506
AT-650E	15	1632	52		650			ESDI
AT-70	8	1024	17		70	27	MFM	ST 506
HCV 345					345	14		SCSI
HCV 650					650	17		SCSI
ZFP 175					175	18		SCSI
ZFP 45					44	29		SCSI
ZFP 90					90	29		SCSI

Sysquest Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
SQ306RD	2	306	17		5			
SQ312RD	2	612	17		11			
SQ325F	4	612	17		22			
SQ338F	6	612	17		33			
SQ555	2	1275			44		RLL	SCSI

TEAC Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
SD-3105-00					105	19	RLL	SCSI
SD-3105-30					105	19	RLL	IDE
SD-3210-00					210	17	RLL	SCSI
SD-3210-30					210	17	RLL	IDE

Toshiba Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
MK134F	7	733	26		66	26	RLL	ST 506
MK134FA	7	733	17		42	25	MFM	ST 506
MK156FA	10	830			143	23	RLL	ESDI
MK156FB	10	830			150	23	RLL	SCSI
MK2024FC					86	19		IDE
MK2124FC					130	17		IDE
MK234FB	7	856			106	20	RLL	SCSI
MK234FC	8	776	33		100	20	RLL	IDE
MK53	5	830	17	512	35		MFM	ST 506
MK54	7	830	17	512	50		MFM	ST 506
MK56FA	10	830	17	512	71		MFM	ST 506
MK56FB	10	830	26		107	24	RLL	ST 506
MK58FA	10	830	17	512	71		MFM	ST 506

Tulin Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
TL226	4	640	17		20		MFM	ST 506
TL238	4	640	17		20		MFM	ST 506
TL240	6	640	17		31		MFM	ST 506
TL258	6	640	26		50		RLL	ST 506
TL326	4	640	17		20		MFM	ST 506
TL338	6	640	17		31		MFM	ST 506
TL340	6	640	17		31		MFM	ST 506

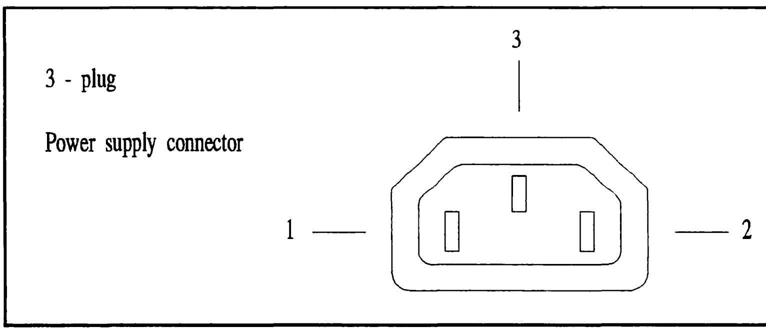
Western Digital Hard Drive Parameters

Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
93044A	5	977	17	0	40			IDE
AC140	5	977	17	0	40			IDE
AC2120	8	872	35	0	125	16		IDE

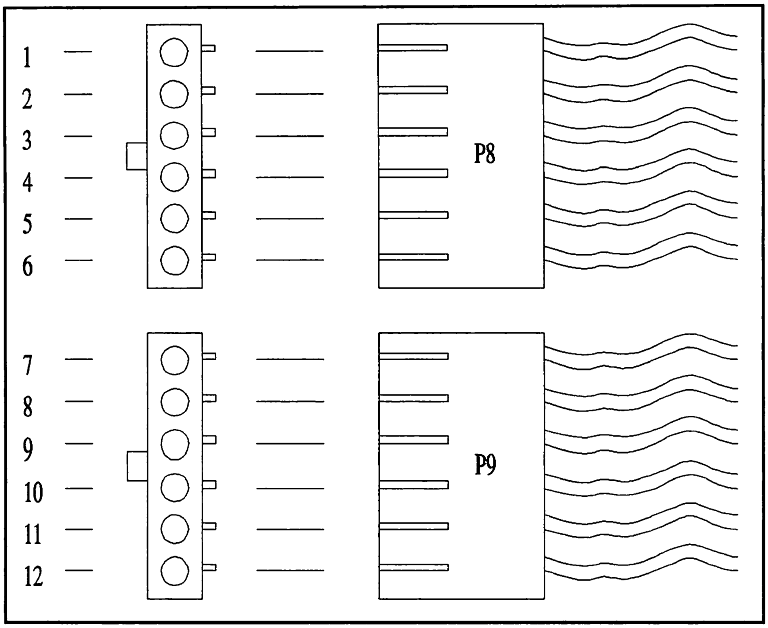
Model	Heads	Cyl	Sect	WPC	Cap	AT	Proc	Port
AC280	10	980	17	0	85			IDE
AC4200	12	987	35	0	212	14		IDE
AP4200	12	987	35		212	16		IDE
SP4200	12	987	35		209	14		SCSI

APPENDIX C Pin Connections

Power Supply Pin Connections

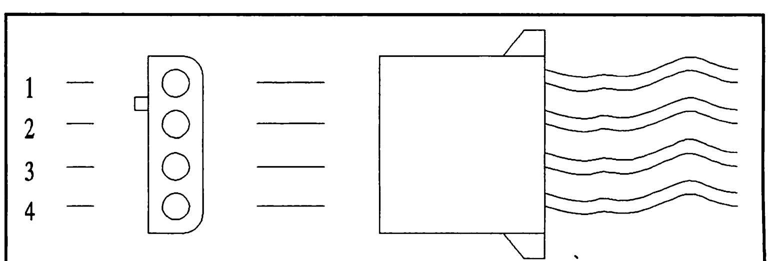


Power Supply Connector Pin Layout	
PIN	Function
1	110V AC
2	110V AC
3	Ground

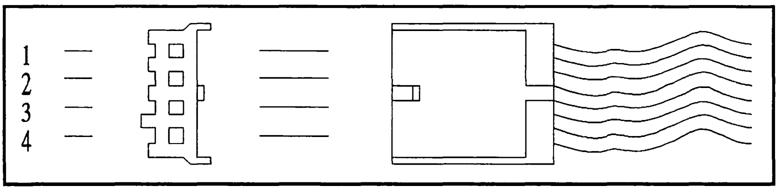


Motherboard Power Supply Pin Layout P8, P9

PIN	Color	Function	PIN	Color	Function
1	Orange	Power Good	2	Red	+ 5V DC
3	Yellow	+ 12V DC	4	Blue	- 12V DC
5	Black	Ground	6	Black	Ground
7	Black	Ground	8	Black	Ground
9	White	- 5V DC	10	Red	+ 5V DC
11	Red	+ 5V DC	12	Red	+ 5V DC

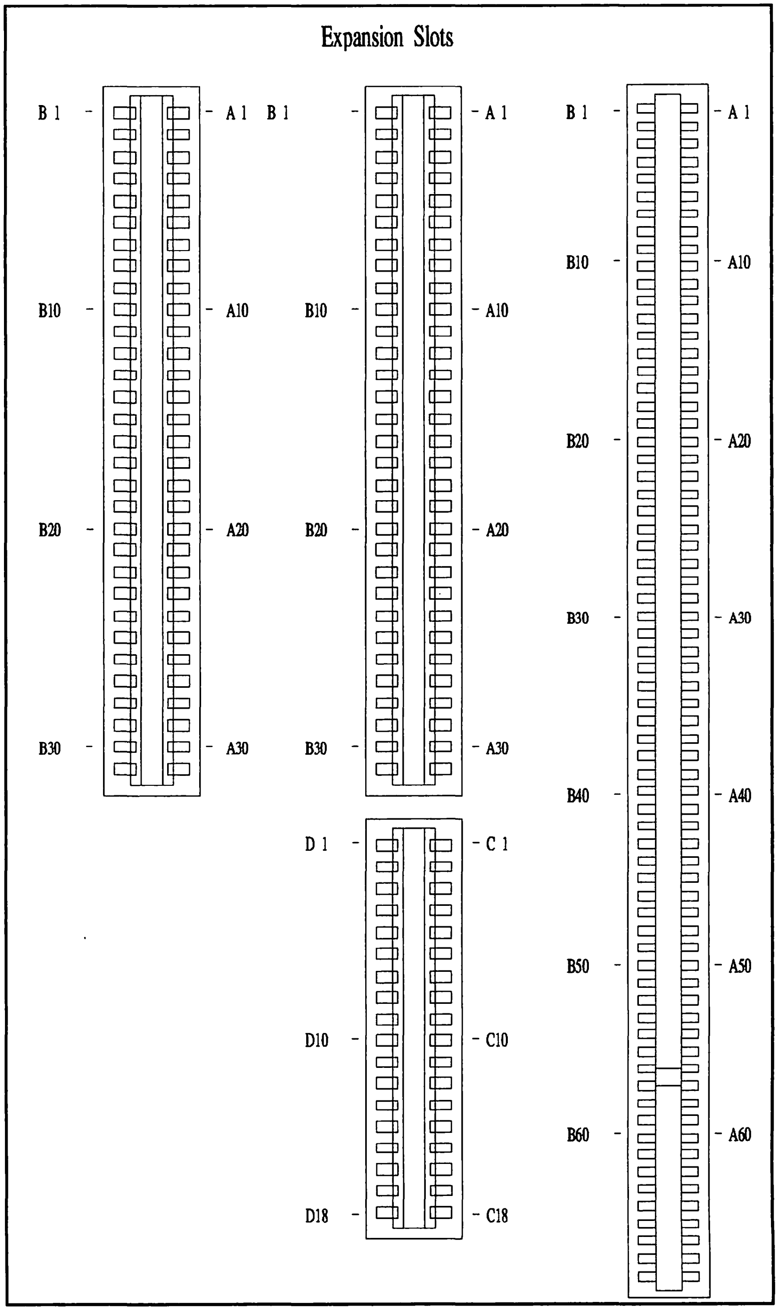


5.25-inch Power Supply Pin Layout					
PIN	Color	Function	PIN	Color	Function
1	Yellow	+ 12V DC	2	Black	Ground
3	Black	Ground	4	Red	+ 5V DC



3.5-inch Pin Layout					
PIN	Color	Function	PIN	Color	Function
1	Yellow	+ 12V DC	2	Black	Ground
3	Black	Ground	4	Red	+ 5V DC

Motherboard



8-Bit ISA Bus Pin Layout

PIN	Function	PIN	Function
A1	I/O CH CK	B1	Ground
A2	D7	B2	Reset Drive
A3	D6	B3	+ 5V DC
A4	D5	B4	IRQ9
A5	D4	B5	- 5V DC
A6	D3	B6	DRQ2
A7	D2	B7	- 12V DC
A8	D1	B8	WS
A9	D0	B9	+ 12V DC
A10	I/O CH RDY	B10	Ground
A11	AEN	B11	SMEMW
A12	A19	B12	SMEMR
A13	A18	B13	IOW
A14	A17	B14	IOR
A15	A16	B15	DACK3
A16	A15	B16	DRQ3
A17	A14	B17	DACK1
A18	A13	B18	DRQ1
A19	A12	B19	Refresh
A20	A11	B20	CLK
A21	A10	B21	IRQ7
A22	A9	B22	IRQ6
A23	A8	B23	IRQ5
A24	A7	B24	IRQ4
A25	A6	B25	IRQ3
A26	A5	B26	DACK2
A27	A4	B27	T/C
A28	A3	B28	BALE
A29	A2	B29	+ 5V DC
A30	A1	B30	OSC
A31	A0	B31	Ground

16-Bit ISA Bus Pin Layout			
PIN	Function	PIN	Function
A1	I/O CH CK	B1	Ground
A2	D7	B2	Reset Drive
A3	D6	B3	+ 5V DC
A4	D5	B4	IRQ9
A5	D4	B5	- 5V DC
A6	D3	B6	DRQ2
A7	D2	B7	- 12V DC
A8	D1	B8	WS
A9	D0	B9	+ 12V DC
A10	I/O CH RDY	B10	Ground
A11	AEN	B11	SMEMW
A12	A19	B12	SMEMR
A13	A18	B13	IOW
A14	A17	B14	IOR
A15	A16	B15	DACK3
A16	A15	B16	DRQ3
A17	A14	B17	DACK1
A18	A13	B18	DRQ1
A19	A12	B19	Refresh
A20	A11	B20	CLK
A21	A10	B21	IRQ7
A22	A9	B22	IRQ6
A23	A8	B23	IRQ5
A24	A7	B24	IRQ4
A25	A6	B25	IRQ3
A26	A5	B26	DACK2
A27	A4	B27	T/C
A28	A3	B28	BALE
A29	A2	B29	+ 5V DC
A30	A1	B30	OSC
A31	A0	B31	Ground

PIN	Function	PIN	Function
C1	BHE	D1	MEM CS16
C2	LA23	D2	I/O CS16
C3	LA22	D3	IRQ10
C4	LA21	D4	IRQ11
C5	LA20	D5	IRQ12
C6	LA19	D6	IRQ15
C7	La18	D7	IRQ14
C8	La17	D8	DACK10
C9	MEMR	D9	DRQ0
C10	MEMW	D10	DACK5
C11	D8	D11	DRQ5
C12	D9	D12	DACK6
C13	D10	D13	DRQ6
C14	D11	D14	DACK7
C15	D12	D15	DRQ7
C16	D13	D16	+ 5V DC
C17	D14	D17	Master
C18	D15	D18	Ground

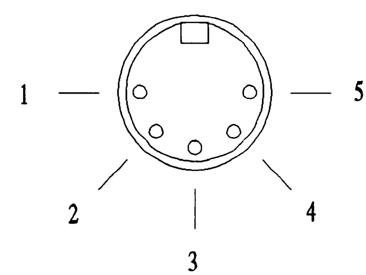
IBM Microchannel Pin Layout

PIN	Function	PIN	Function
A1	SETUP	B1	Audio/GROUND
A2	M_ADE 24	B2	Audio
A3	GROUND	B3	GROUND
A4	A11	B4	OSC
A5	A10	B5	GROUND
A6	A9	B6	A23
A7	+ 5V DC	B7	A22
A8	A8	B8	A21
A9	A7	B9	GROUND
A10	A6	B10	A20
A11	+ 5V DC	B11	A19
A12	A5	B12	A18
A13	A4	B13	GROUND
A14	A3	B14	A17

PIN	Function	PIN	Function
A15	+ 5V DC	B15	A16
A16	A2	B16	A15
A17	A1	B17	GROUND
A18	A0	B18	A14
A19	+ 12V DC	B19	A13
A20	ADL	B20	A12
A21	PREEMPT	B21	GROUND
A22	BURST	B22	IRQ9
A23	- 12V DC	B23	IRQ3
A24	ARBO	B24	IRQ4
A25	ARB1	B25	GROUND
A26	ARB2	B26	IRQ5
A27	- 12V DC	B27	IRQ6
A28	ARB3	B28	IRQ7
A29	ARB/Ground	B29	GROUND
A30	TC	B30	Unused
A31	+ 5V DC	B31	Unused
A32	S0	B32	CHCK
A33	S1	B33	GROUND
A34	M/10	B34	CMD
A35	+12V	B35	CHRDYRTN
A36	CD CHRDY	B36	CD SFDBK
A37	D0	B37	GROUND
A38	D2	B38	D1
A39	+ 5V DC	B39	D3
A40	D5	B40	D4
A41	D6	B41	GROUND
A42	D7	B42	CHRESET
A43	GROUND	B43	Unused
A44	DS 16 RIN	B44	Unused
A45	REFRESH	B45	GROUND
A46	/	B46	/
A47	/	B47	/
A48	+ 5V DC	B48	D8
A49	D10	B49	D9
A50	D11	B50	GROUND
A51	D13	B51	D12

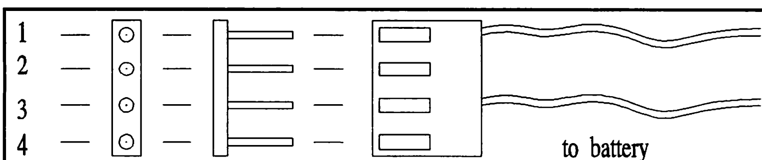
PIN	Function	PIN	Function
A52	+ 12V DCB52	D14	
A53	Unused	B53	D15
A54	SBHE	B54	GROUND
A55	CD DS 16	B55	IORQ10
A56	+ 5V DC	B56	IORQ11
A57	IRQ14	B57	IORQ12
A58	IRQ15	B58	GROUND

5-pin din connector



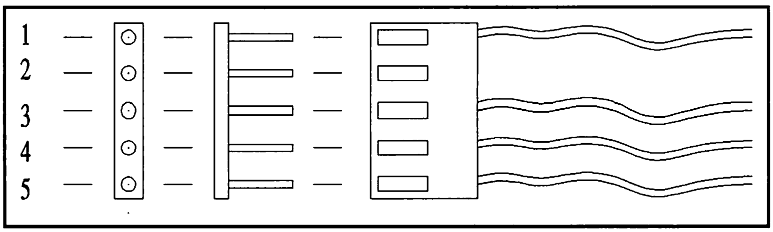
AT Keyboard Jack Pin Layout

PIN	Function	PIN	Function
1	Clock	2	Data
3	Reset	4	Ground
5	+ 5V DC		



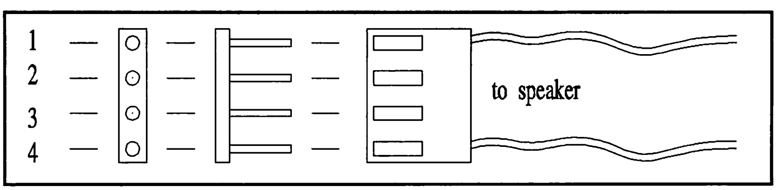
Battery Connector Pin Layout

PIN	Color	Function	PIN	Color	Function
1	+6V DC	Red	2	Unused	/
3	Ground	Black	4	Ground	/



LED Keylock Connector Strip Pin Layout

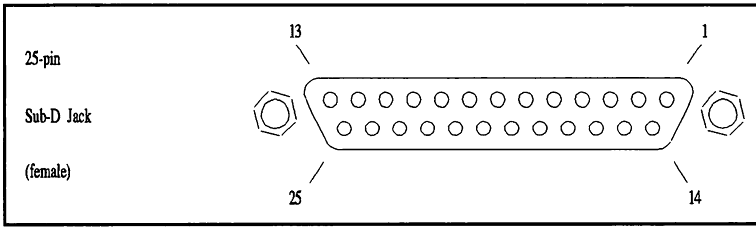
PIN	Function	PIN	Function
1	Power LED Anode	2	Unused
3	Ground	4	Keyboard lock
5	Ground		



Loudspeaker Connector Pin Layout

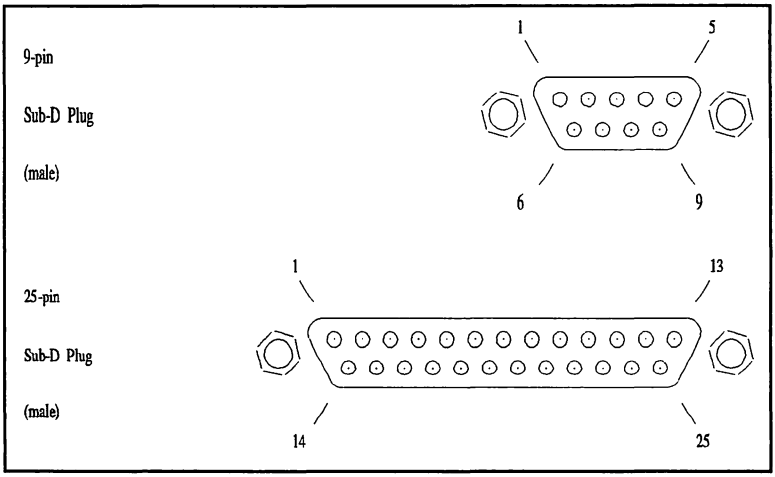
PIN	Function	PIN	Function
1	Signal	2	+5V DC
3	Ground	4	+5V DC

Ports Pin Layouts



Parallel Port Pin Layout

PIN	Function	PIN	Function
1	Strobe	2	BIT 1
3	BIT 2	4	BIT 3
5	BIT 4	6	BIT 5
7	BIT 6	8	BIT 7
9	BIT 8	10	Acknowledge
11	Busy	12	Paper out
13	Select out	14	Autofeed
15	Error	16	Printer Reset
17	Select in	18	Ground
19	Ground	20	Ground
21	Ground	22	Ground
23	Ground	24	Ground
25	Ground		

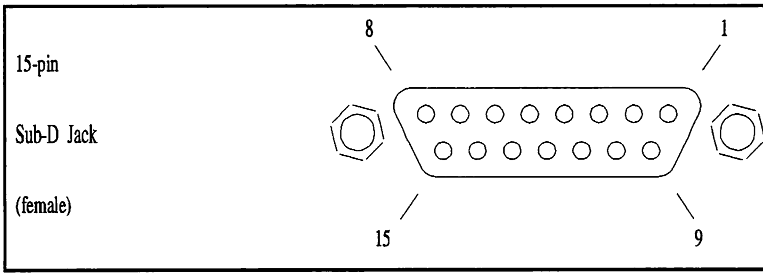


9-Pin Serial Port Pin Layout

PIN	Function	PIN	Function
1	Carrier detect	2	Receive Data
3	Transmit data	4	Data terminal ready
5	Ground	6	Data set ready
7	Request to send	8	Clear to send
9	Ring indication		

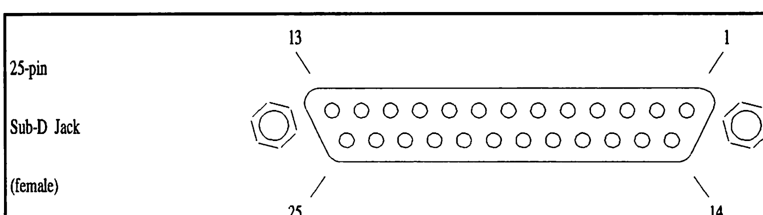
25-Pin Serial Port Pin Layout

PIN	Function Function	PIN	
1	Ground	2	Transmit Data
3	Receive Data	4	Request to send
5	Clear to send	6	Data set ready
7	Ground	8	Carrier detect
9	Check modem	20	Data terminal ready
		22	Ring indication



Gameport Pin Layout

PIN	Function	PIN	Function
1	+5V DC	2	Joystick 1, first button
3	Joystick 1, X-Position	4	Ground
5	Ground	6	Joystick 1, Y-Position
7	Joystick 1, sec button	8	+5V DC
9	+5V DC	10	Joystick 2, first button
11	Joystick 2, X-Position	12	Ground
13	Joystick 2, Y-Position	14	Joystick 2, second button
15	+5V DC		

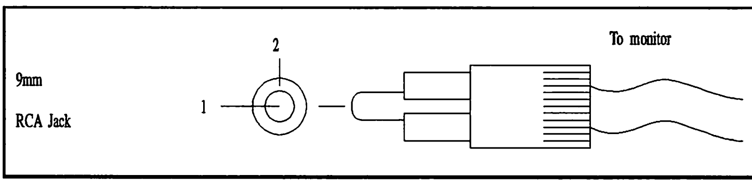


External Floppy Connector Pin Layout

PIN	Function	PIN	Function
1	Index	2	Motor on, Drive 4

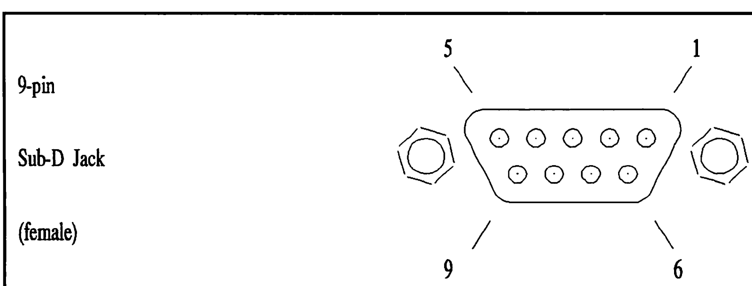
3	Drive select, Drive 3	4	Drive select, Drive 4
5	Motor on, Drive 3	6	Direction
7	Step	8	Write Data
9	Write Gate	10	Track 0
11	Write protect	12	Read Data
13	Side 1 select	14	+ 5V DC
15	+ 5V DC	16	+ 5V DC
17	n.c.	18	Power on
19	Ground	20	Ground
21	Ground	22	Ground
23	Ground	24	Disk change
25	High density		

Screen Adapter Pin Connections



Composite Jack Pin Layout

PIN	Function	PIN	Function
1	Ground	2	Signal



Connection to a Monochrome Display Adapter

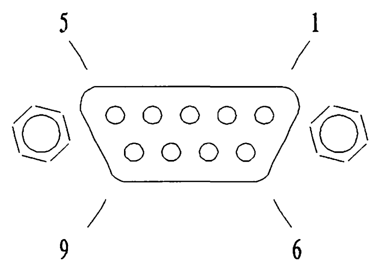
MDA/Hercules Adapter Pin Layout

PIN	Function	PIN	Function
1	Ground	2	Unused
3	Unused	4	Unused
5	Unused	6	Intensity
7	Video signal	8	Horizontal synch
9	Vertical synch	9	Vertical synch

9-pin

Sub-D Jack

(female)



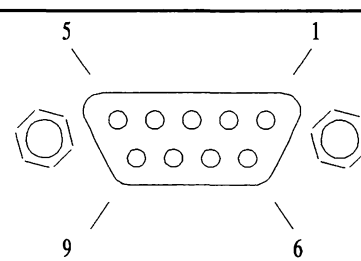
CGA Card Pin Layout

PIN	Function	PIN	Function
1	Ground	2	Unused
3	Red	4	Green
5	Blue	6	Intensity
7	Unused	8	Horizontal synch
9	Vertical synch		

9-pin

Sub-D Jack

(female)



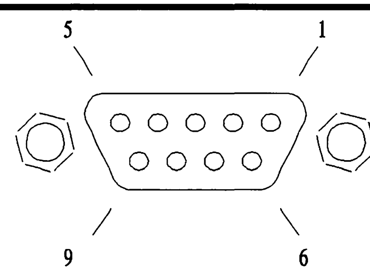
EGA Card Pin Layout

PIN	Function	PIN	Function
1	Ground	2	2. Red
3	Red	4	Green
5	Blue	6	2. Green
7	2. Blue	8	Horizontal synch
9	Vertical synch		

9-pin

Sub-D Jack

(female)



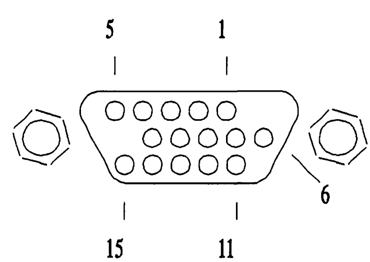
9-Pin VGA Connector Pin Layout

PIN	Function	PIN	Function
1	Ground	2	2. Red
3	Red	4	Green
5	Blue	6	2. Green
7	2. Blue	8	Horizontal synch
9	Vertical synch		

15-pin

Sub-D Jack

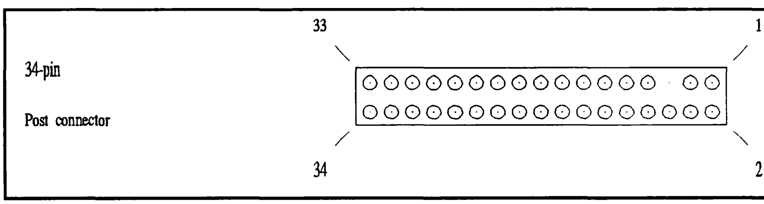
(female)



15-Pin VGA Connector Pin Layout

PIN	Function	PIN	Function
1	Red	2	Green
3	Blue	4	Monitor ID 2
5	Unused	6	Ground
7	Ground	8	Ground
9	Unused	10	Ground
11	Monitor ID 0	12	Monitor ID 1
13	Horizontal synch	14	Vertical synch
15	Unused		

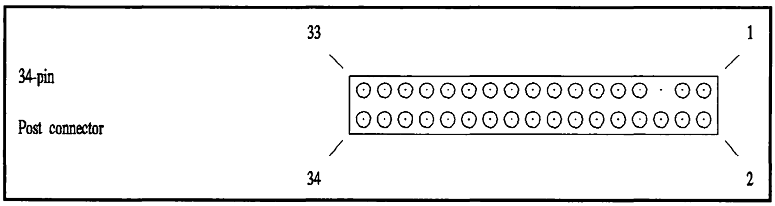
Controller Pin Connections



Floppy Connector Pin Layout

PIN	Function	PIN	Function
1	Ground	2	HL
3	/	4	In use
5	Ground	6	Drive Select 3
7	Ground	8	Index
9	Ground	10	Drive Select 0
11	Ground	12	Drive Select 1
13	Ground	14	Drive Select 2
15	Ground	16	Motor on
17	Ground	18	Direction
19	Ground	20	Step
21	Ground	22	Write Data
23	Ground	24	Write Gate
25	Ground	26	Track 0

PIN	Function	PIN	Function
27	Ground	28	Write protect
29	Ground	30	Read Data
31	Ground	32	Side select
33	Ground	34	Disk change



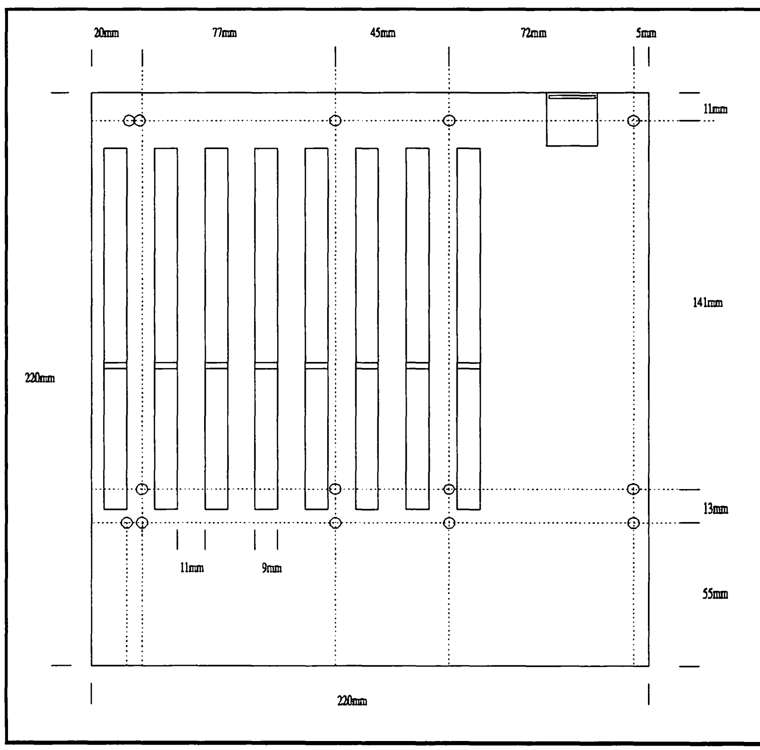
IDE-Interface Pin Layout

PIN	Function	PIN	Function
1	Reset	2	Ground
3	D7	4	D8
5	D6	6	D9
7	D5	8	D10
9	D4	10	D11
11	D3	12	D12
13	D2	14	D13
15	D1	16	D14
17	D0	18	D15
19	Ground	20	locked
21	IOCHRDY	22	Ground
23	IOWR	24	Ground
25	IORD	26	Ground
27	IOCHRDY	28	ALE
29	Unused	30	Ground
31	IRQ14	32	IO16
33	A1	34	A0
35	A2	36	PDIAG
37	CS0	38	CS1
39	HD-LED active	40	Ground

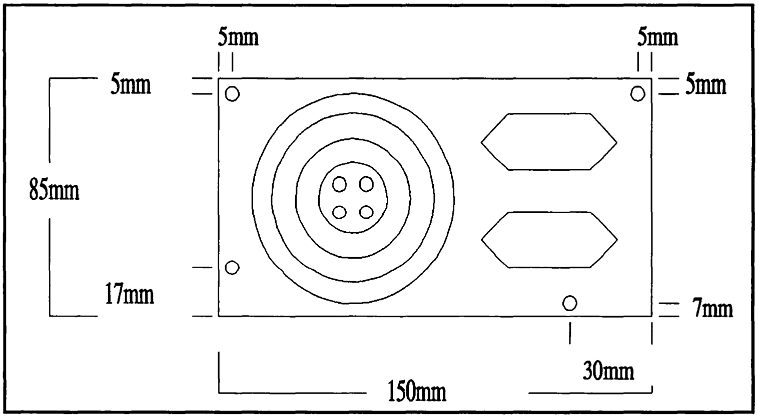
APPENDIX

D Standard Measurements

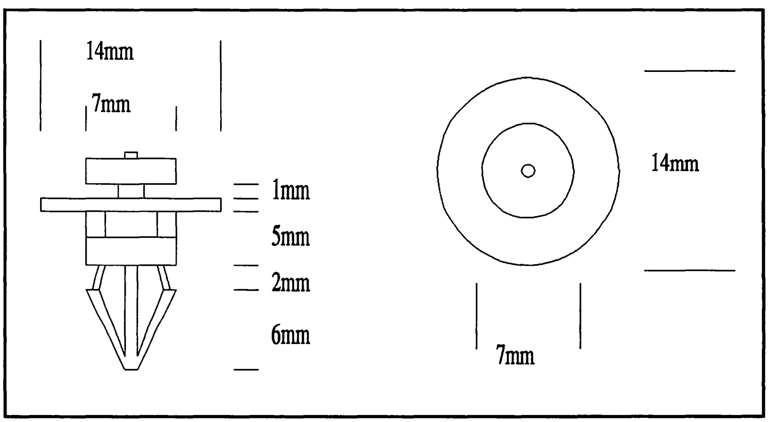
Dimensions Of A Mini-board



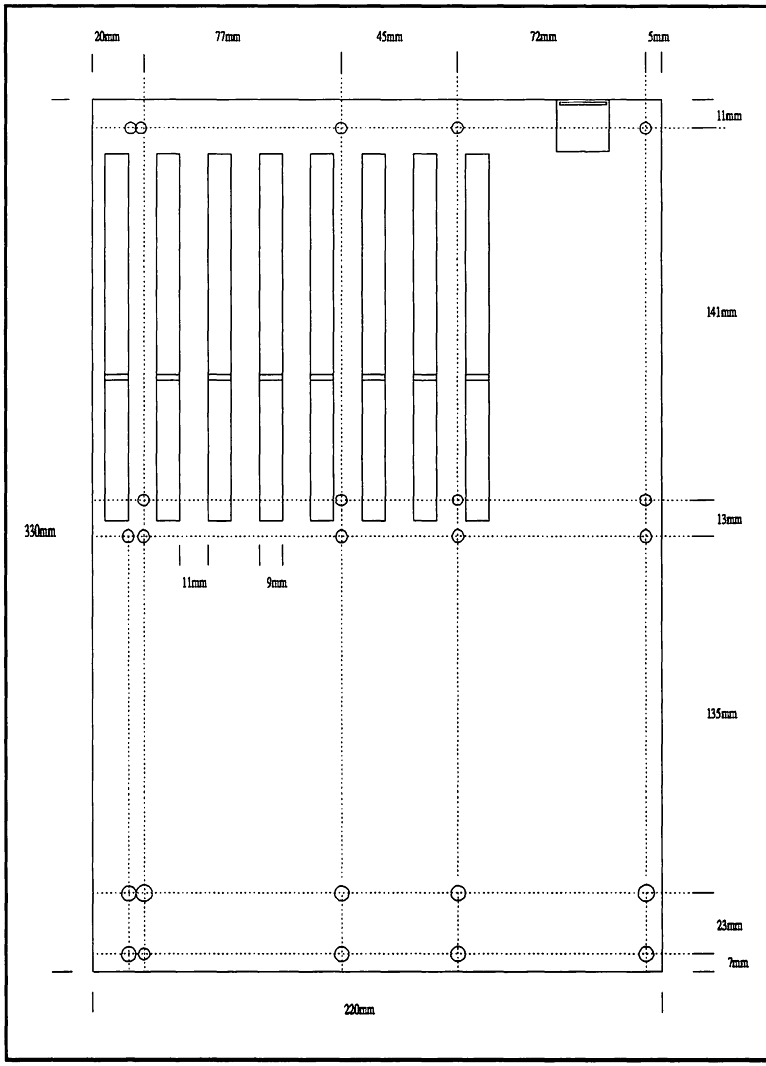
Compact Power Supply Dimensions



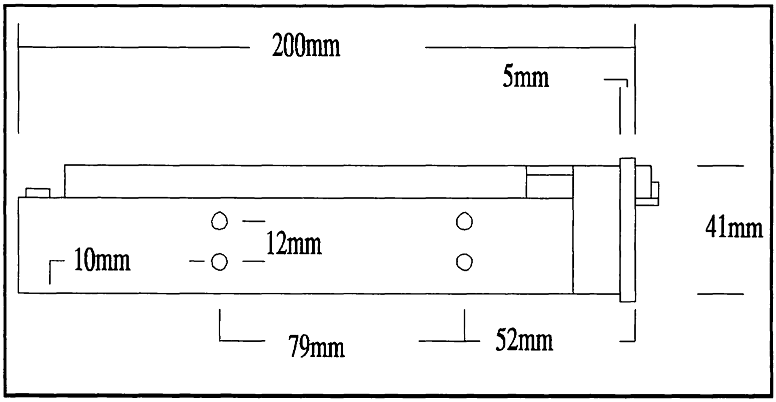
Average Separator



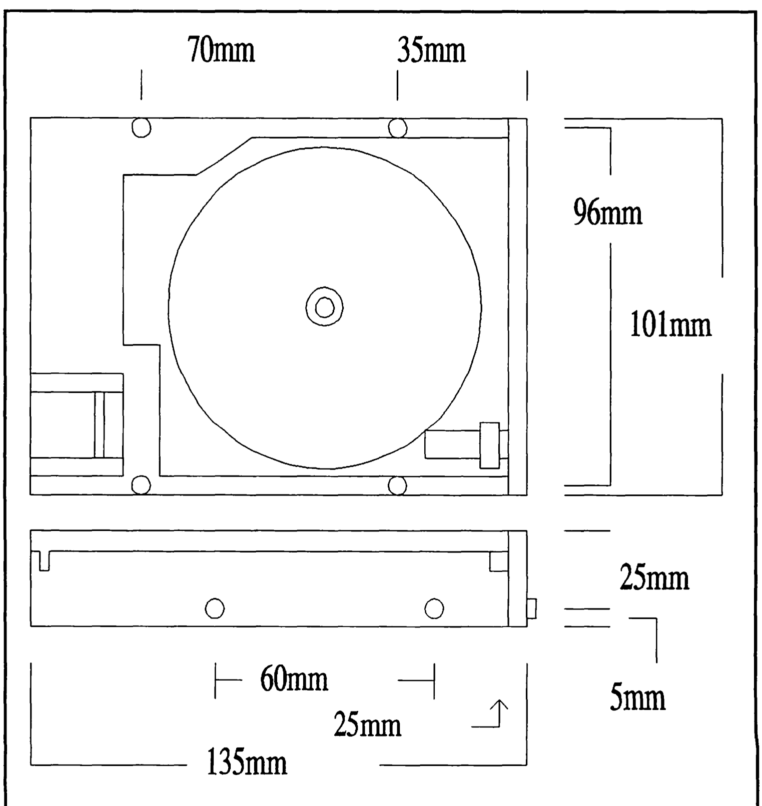
Motherboard Measurements



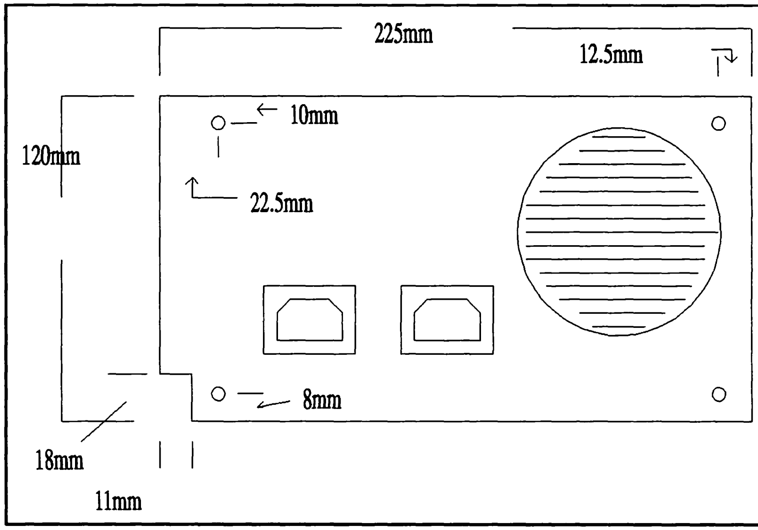
Screw Positions On a 5.25-inch Drive



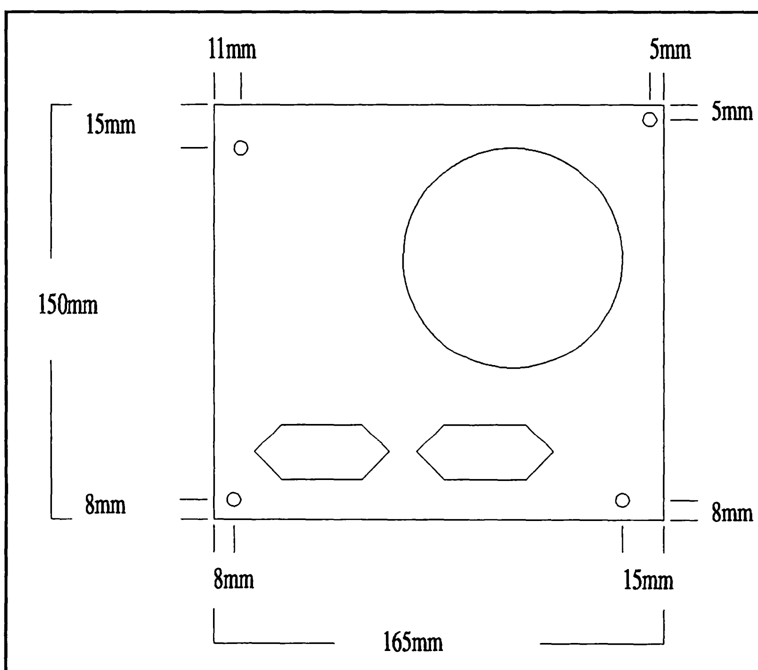
Screw Positions On a 3.5-inch Drive



XT/AT Power Supply Dimensions



Cube Power Supply Dimensions



APPENDIX E
Glossary

3.5-inch diskette
A specific size of a storage device. They have more storage capacity and are more rugged and portable than 5.25-inch disks. See also *Diskette.*

5.25-inch diskette
A specific size of a storage device. This type of disk can store up to 1.2 Meg of data or approximately 1,200,000 characters of text. See also *Diskette.*

8086 processor
An Intel microprocessor developed in 1978. It features a full 16-bit data bus and can address 1 Meg of memory.

8088 processor
An Intel microprocessor developed in 1978. It features an 8-bit external data bus (for disk drives, etc.) and an internal 16-bit data bus. It was used in the original IBM-PC computers and can address 1 Meg of RAM.

80286 processor
Also called a "286". An Intel microprocessor developed in 1984. It features 16-bit registers and a 16-bit data bus. The 286 processor can address 16 Meg of RAM (in Protected mode).

80287 math coprocessor
An Intel math coprocessor that adds over 50 new instructions to the CPU. It performs floating-point math much faster and more accurately than the main CPU. Designed for most 286-based and some 286DX-based systems.

80386 processor
Also called a "386". An Intel microprocessor that features 32-bit registers, a 16-bit data bus, and a 24-bit address bus.

80387DX math coprocessor

An Intel math coprocessor that adds over 50 new instructions to the CPU. It performs floating-point math much faster and more accurately than the main CPU. Designed for most 386DX-based systems.

80387SX math coprocessor

An Intel math coprocessor that adds over 50 new instructions to the CPU. It performs floating-point math much faster and more accurately than the main CPU. Designed for most 386SX-based systems.

80486 processor

Also called a "486". An Intel microprocessor that features 32-bit registers, a 32-bit data bus, and a 32-bit address bus. The 486 can operate in Real, Protected Virtual, and Virtual Real modes. Includes a built-in cache memory. Also includes a built-in math coprocessor similar to a 80387SX.

80486SX processor

An Intel microprocessor that features 32-bit registers, a 32-bit data bus, and a 32-bit address bus. The 80486SX is similar to the 80486 except it doesn't include a math coprocessor.

8087 math coprocessor

An Intel math coprocessor that performs floating-point math much faster and more accurately than the main CPU. Designed for most 8086- and 8088-based systems.

8514/A

An analog video display card for the PS/2 computer. It provides a high resolution of 1024x768 pixels and 256 colors or 64 shades of gray.

Accelerator board

A board that contains a microprocessor that's faster or more powerful than the one currently installed in your computer. For example, PC users can purchase accelerator cards that contain the faster 80286 or 80386 processors.

Access time

The time that elapses from the moment the information is requested to the point that the task is completed. This is normally described in nanoseconds for memory chips. The IBM PC requires 200-nanosecond memory chips and the AT requires 150-nanosecond chips.

Adapter

This is a device that serves as an interface between the system and other devices connected to it.

ADC
Acronym for Analog to Digital Converter, which transforms analog signals to digital samples.

Address
The Intel processors (80xx) form an address from one of the four segment registers with another register or constant. The contents of the segment address becomes the segment address and the other registers or constant becomes the offset address. Both addresses are logical addresses related to a physical address.

Address Bus
A line connecting the CPU with ROM and RAM memory. When the CPU addresses a memory location, it must first place its address on the address bus in order to set the "switches" for access to this memory location.

API
An acronym for Application Program Interface. This is a routine that gives users access to the services provided by the operating system.

Application
A program designed for a specific purpose. Word processors, spreadsheets, and databases are applications.

Archive bit
A bit in a file's attribute byte that sets the archive attribute. This lets you know whether the file has been changed since the last backup.

ASCII
Acronym for American Standard Code for Information Interchange. ASCII is the standard for keyboard character codes. The ASCII standard covers key codes 0 to 127; individual computer manufacturers assign their own character to codes 128 to 255.

AT
Acronym for Advanced Technology. The AT is essentially the "big brother" of the PC. It has a more powerful microprocessor, a higher processing speed in most cases, larger memory capacity beyond the 640K limit set by the old PC configuration, and higher disk storage capacity.

Attribute byte
This is a byte of information that describes various attributes of the file. This is stored in the directory of any file and indicates whether or not it's read-only or whether it has been backed up since it was last changed.

AUTOEXEC.BAT
Abbreviation for AUTOEXECute BATch file. This is a text file containing a series of commands stored in a group. After you switch on the PC, it searches for an AUTOEXEC.BAT file. If one exists, the commands execute automatically. AUTOEXEC.BAT can also be called and executed directly from the system prompt.

Average seek time
The average time required for a disk drive's read/write heads to move from one track to another.

Backup copy
Duplicate of an original disk or file. Making backup copies is a good habit to develop. Data on a disk can easily and accidentally be destroyed.

Bad Track Table (BTT)
Very few hard drives are available without certain defective tracks. Most manufacturers enclose a data sheet ("table") listing the defective sectors or other areas of the hard drive. See also *Low-level format.*

Bandwidth
The measure of the range of frequencies within a radiation band required to transmit a certain signal. The bandwidth of a monitor is a measure of the rate that a monitor can handle information from the display adapter.

Bank switching
A method of expanding memory beyond the normal memory limits by quickly switching between two banks of memory chips.

Base memory
The first, or lower, 640K of the first megabyte of memory.

Basic Input/Output System
See *BIOS.*

Batch file
A file containing a collection of commands. MS-DOS executes these commands in sequence when the user enters the name of the file. Other terms are batch processing or batch job. The .BAT extension must be included with any batch filename.

Baud
The unit used to measure the rate of data transmission. A baud is approximately 1 bit per second.

Baud rate

The number of signal events (the signal for a 1 bit and the signal for a 0 bit are both "events") that take place on a communications line each second. Standard baud rates include 300 baud, 1200 baud, 2400 baud, etc.

Beep code

A sequence of short or long beeps made by your PC during the Power-On Self-Test to indicate a problem.

Bernoulli box

A type of mass storage device featuring removable cartridges that contain a rapidly spinning diskette similar to a floppy diskette. The high speed of rotation and the small distance between the head and the disk make a high recording density possible and give the Bernoulli disk a memory capacity comparable to a hard drive.

Binary

A number system consisting of only two numbers (0,1), sometimes called bits. Unlike the decimal number system with its 10 numbers (0-9), the binary number system is better suited to the internal structure of a computer. Both number systems rely on the positional value of numbers. In the binary system the column value increases as follows: 0, 2, 4, 8, 16, 32, etc.

BIOS

Acronym for Basic Input Output System. BIOS is a program permanently stored in the memory of the computer and is available without an operating system disk. For example, it performs the internal self test of the computer and searches for the operating system (MS-DOS) on the disk in the drive.

Bit

The smallest unit in the binary number system. It can only assume two states (0,1) and therefore store only two different pieces of information. To store a character, several bits must be combined into a byte.

Block

A string of records, words, or characters formed for technical or logical reasons and is treated as a whole.

Boolean operation

Any operation in which each of the operands and the result take one of two values.

Boot/Reboot

The loading process that places the operating system in memory. A disk used for booting a PC must have two "hidden" files available for telling the PC to boot, as well as the COMMAND.COM file.

Bootable
A disk that can be used for booting. See also *Boot*.

BPS
An acronym for Bits Per Second. The number of binary digits or bits that's transmitted per second.

Buffer
A block of memory used to store data temporarily. All data moving between the peripheral and the computer passes through the buffer. A buffer enables the data to be read from or written to the peripheral in larger chunks.

Bus
A collection of communication lines transmitting signals between components on a circuit board or between the circuit board and expansion or other cards.

Byte
A group of eight bits. While a bit can only assume two states, 0 and 1, a byte can store from 0 to 255 conditions. The standard ASCII character set consists of 128 characters; the additional characters generally used in PC software increase the total number of characters to 255.

Cache
A special area of RAM to store the most frequently accessed information in RAM. You can significantly improve the speed of your system by using cache memory because it "optimizes" the cooperation among the different components of your system.

Card-edge connector
Part of the card with metal "fingers" which match the expansion slot connector.

Cartridge system
A removable module, or cartridge, containing a magnetic tape or diskette and used as a storage device.

Cathode Ray Tube (CRT)
A device that generates a screen display with the help of an electron beam that sends electrical impulses to a glass screen at the end of the CRT.

CD-ROM
An acronym for compact disc read-only memory. A CD-ROM includes extremely high data density and storage capacity of approximately 680 Meg per disk. It's used in multimedia applications.

CD-ROM disk drive

A storage device that uses compact disks (CDs) to store data. Although a large amount of data can be stored on these disks, they're "Read Only Memory" disk drives.

CD-WORM disk drive

A storage device based on further development of CD-ROM disk drives. It's an acronym for "Write Once Read Many". These disk drives can write on the CD only once but read it as often as required.

Centronics

Standard connection between the PC and a printer. The connection of other devices to the PC occurs through interfaces. There are serial interfaces, in which data is sent as individual bits, and parallel interfaces, in which a byte can be transmitted simultaneously.

CGA

See *Color Graphics Adapter*.

Chip

Complicated electronic circuitry built into a small space. The early days of electronics required huge circuits. Chips compressed this same circuitry into a single silicon chip, and made it possible to develop small computers for the home. The most important chip in the PC is the microprocessor, which does most of the basic tasks needed in a computer.

CHKDSK

Abbreviation for CHecKDiSK. A transient command (read from the DOS disk). CHKDSK A: tests the disk in drive A:, then displays the volume name of the disk and the date and time the disk was formatted. In addition, the total capacity and the overview of the file types and number of files are displayed. CHKDSK also tells the user of any errors on the disk and asks the user if those errors should be corrected. The remaining space on the disk is also indicated. At the end of the display, two lines indicate the total memory available in the PC and how much memory space is still available to the user.

CISC

Acronym for Complex Instruction-Set Computer. This refers to computers that operate with large sets of processor instructions.

Clock frequency

The speed of the processor is measured with the clock frequency. Unlike people, the processor consistently works internally at the same clock frequency. The IBM PC has

a clock frequency of 4.77 MHz (Megahertz). Compatibles sometimes use higher frequencies, but higher speeds may create compatibility problems.

Clone
Another word to describe an IBM compatible computer.

Cluster
A group of sectors that forms a unit of storage to the operating system. The size is determined by DOS when the disk is formatted. Also called allocation unit.

CMOS
A Complementary Metal-Oxide Semiconductor that pretends to duplicate the functions of memory chips or other processors. CMOS chips are used primarily in portable PCs, which receive their power from batteries.

Cold start
Switching the computer off and on. Unlike the warm start, the cold start involves completely switching the computer off and then switching it on again. The cold start is the last chance to have the computer start completely new. Since switching the computer off and on puts much stress on the electronic components, use the warm start (Ctrl+Alt+Del) whenever possible.

Color Graphics Adapter (CGA)
A bit-mapped graphics card that can display several colors at the same time (the amount depends on the CGA monitor you're using). The CGA card has three possible graphics modes.

COMMAND.COM
An operating system file that's loaded last when the computer is booted. This is the command interpreter or user interface of DOS.

Compatible/Compatibility
Hardware and software that work together. A computer that is fully IBM compatible should be able to execute all programs that exist for the IBM PC.

CONFIG.SYS
A file that's created to inform DOS how to configure itself when the machine is started.

Configuration
The collection of devices that comprise the complete computer system (see *Hardware*). Configuration may also refer to the software integration of the devices. For example, the software configuration for serial interface operation of a printer

includes the preparation of software drivers, which instruct the computer to use this configuration.

Controller card
A card (adapter) that connects the disk drive(s) to the computer.

Coprocessor
Name for electronic components (see *Chip*) that relieve the microprocessor of some important tasks. Increased performance can often be achieved through the use of coprocessors. For example, a math coprocessor often performs many of the math functions that can slow down the microprocessor during complicated graphic computations.

CPU
Abbreviation for Central Processing Unit. This is the main microprocessor of the PC; sometimes it's also used to describe the PC's case.

Current directory
To access a file or a directory, DOS uses the current directory. A directory can be made into the current directory by indicating the position relative to the current directory or giving the complete pathname. In the first case, use the CD .. and CD NAME commands. In the second case, first the drive (letter and colon) and then the path through the subdirectories must be indicated, separated by the backslash.

Current drive
The standard drive or current drive is the drive to which all disk commands of the computer apply. Usually, and especially for systems with only one drive, this is drive A:. If two drives are available, the second drive can be selected with B:. This command can be reversed with A:. The hard drive can be selected with C:. The standard drive is displayed in the system prompt (see *Prompt*).

Cursor
A small, rectangular, blinking spot of light on the screen that marks the spot where a character can be placed from the keyboard. The arrow keys (also called cursor keys) move the cursor back and forth.

Daisywheel printer
Daisywheel printers use a typewriter-like wheel. Individual letters press a character on the paper, instead of composing the character from a matrix of dots like the matrix printers. The quality of the printing is comparable to that of a typewriter.

Databases
Application programs that enable you to access data quickly. Many database programs allow different sets of data to be combined into one package, which permits access to the different data sets simultaneously.

Databus
A line used to transmit data between the CPU and RAM or ROM memory.

Data transfer rate
The rate that data is transferred from a computer to a disk drive or from one computer to another computer.

Default
Any setting assumed at start-up or reset by the computer's software and devices. This setting is used until it's changed by the user.

Device driver
A subprogram to control communications between the computer and a peripheral.

Dhrystone
A benchmark program used to measure and compare the performance of computers in areas other than floating-point math operations.

Digital to Analog Converter (DAC)
A device used to convert digital numbers to continuous analog signals.

Digitizing tablets
An input device that converts graphic and pictorial data into binary inputs.

DIP switch
A series of small switches used by computers and peripherals to configure the equipment.

DIR
A DOS command used to display the directory of the current drive.

Directory
Part of a storage medium. Before the hard drive was commonly used, all files were stored in one directory called the root directory. Because of the capacity of the hard drive, it had to be divided into various directories. These directories are arranged in a tree structure where the root directory can contain files and subdirectories. Every subdirectory in turn can contain files and subdirectories. Most DOS commands act only on the current directory, which can be indicated with CD.

Disk drive

Disk drives are devices that permit the PC to work on the data stored on the disk. Depending on the size and type of the disks, there are drives for 5.25-inch diskettes and for 3.5-inch diskettes. If the PC wants to read in the MS-DOS operating system, first it accesses the upper or left drive, depending on the construction of the PC. This is the main drive. Its designation is A:. The other drive is then drive B:. If there is a hard drive, it has the designation drive C:. Only one drive can be active. Its drive letter appears in front of the system prompt on the screen and is constantly displayed on the screen.

Diskette

Removable data storage media. PC systems use two sizes. When purchasing new diskettes, ensure that they are double sided and double density. Double sided means that the PC can write on both sides. Double density refers to the density of the magnetic material coating.

DMA

Acronym for Direct Memory Access. A circuit that permits a high-speed transfer of data between a device and system memory.

DOS

See *MS-DOS*.

Dot-matrix printer

Printer that produces characters on paper by driving a set of pins onto a ribbon, which leaves an impression of a character on paper.

Double density

Double density means that this type of disk has twice as much magnetic material for recording as a single density disk. Use double density disks only for PCs.

Double sided

A disk that is double sided can record on both sides.

Dynamic RAM Chips (DRAM)

A RAM chip that must be continuously refreshed. These chips vary in their access time, which is measured in nanoseconds.

EISA

An acronym for Extended Industry Standard Architecture (an extension of the (ISA) Industry Standard Architecture). This is a bus standard that extends the AT bus architecture to 32-bits and allows more than one CPU to share the bus.

Electrostatic discharge

Static electricity that can cause integrated circuit damage or failure. Make sure you are grounded before touching any computer components.

Empty directory

A directory containing no files or subdirectories. When the DIR command is activated from within an empty directory, entries with one or two periods and a <DIR> identifier are displayed instead of filenames. The identifier is required by DOS. Move up one directory level and enter CD .. to remove an empty directory. Then enter the RD command.

Enhanced Graphics Adapter (EGA)

A high resolution graphics card that has a superior resolution compared to the CGA standard. The EGA combined the operating modes of the MDA and the CGA. The EGA is capable of displaying all 16 colors in text mode with a resolution of 640 x 350 pixels.

EPROM

Acronym for Erasable Programmable Read Only Memory. This is a ROM chip that can be erased and reprogrammed many times. These chips are erased by ultraviolet light and should not be exposed to direct sunlight.

ESDI

An acronym for Enhanced System Device Interface. Hard drives using this standard transfer data 2.5 times faster than the earlier ST506 standard.

Expanded memory

Memory above the 640K limit for DOS Version 3.3 (and earlier versions) that can be used for programs requiring large amounts of memory. Remember that this area of memory requires special drivers and works only with software written for it.

Expanded Memory Specification (EMS)

This provides a way for microcomputers running under DOS to access additional memory.

Expansion card

A printed circuit card that you can install to add new features and expand the current capabilities of your system.

Expansion slots

Slots or spaces inside the case for connecting cards to the motherboard. Most PCs have these slots so it's easy to upgrade the system.

Extended DOS partition

These are non-bootable partitions that define other logical drives in your system.

Extended memory

Area of memory above 1 Meg that can be accessed by a computer using a 286, 386, or 486 processor.

External hard drive

A hard drive that isn't located inside the case of the PC. Instead, it's outside of the case and connected by cables.

Extra-high density (ED)

The storage capacity of a floppy drive or diskette, in which 36 sectors per track are recorded using a vertical recording technique with MFM encoding.

File

Data stored under a name assigned by the user or manufacturer. Data files (e.g., programs, text, graphics, etc.) appear in the directory of a diskette or hard drive as an entry containing the name, extension, size, and date of storage.

File Allocation Table (FAT)

A portion of all DOS formatted diskettes that contains information on the number and location of files and available storage space.

File attribute

Information stored in the file's attribute byte.

File management

Working with data. Related information is stored in a data set and these are presented in sorted format. An address file is a simple form of file management.

File structures

The type and method of storing files on a medium. The root directory can contain both files and subdirectories, and any subdirectory can also contain files and subdirectories.

Filename

A group of letters and numbers indicating a specific file stored in a directory. A filename consists of the filename itself, which can be up to eight characters long; and the extension, which can have a maximum of three characters. Spaces aren't allowed in filenames and result in error messages.

Floppy diskette

A removable storage medium. It is a round disk of flexible material that's housed in a square envelope or cartridge. Early disks were 8 inches square and inflexible. When the first 5.25-inch disks appeared on the market, people referred to them as "floppy disks."

Floppy disk controller

The card or chip that controls the floppy disk drive.

FORMAT

Formatting a disk (preparing a disk to store data). Before the command can be used, the DOS disk must be inserted into the drive. Since the FORMAT command is transient, it must be read from the DOS disk before it can be used.

Formatted capacity

The amount of available storage space remaining on the diskette after formatting. It's always less than the capacity before formatting.

Full-height drive

A drive unit that is 3.25 inches high, 5.75 inches wide, and 8-inches deep.

General error

The error message displayed by the PC when it cannot access a disk drive:

The error can be caused by the following: Failure to insert a disk into the drive; the drive is not closed or locked; or the disk that was inserted isn't formatted. The best remedy is to insert a formatted disk, lock the drive, and press A (Abort). The normal system prompt should appear.

Gigabyte (Gb)

A unit of measure equal to 1024 Meg.

Ground

To make an electrical current connection to the earth or a conductor of equivalent effect.

Half-height drive

A drive unit that's 1.625 inches high and either 5.75 or 4 inches wide and 4 or 8 inches deep.

Hard drive

A hermetically sealed disk drive that usually cannot be removed from the PC (a few newer models are removable). Hard drives have much higher storage capacities than floppy disks. 20 megabyte hard drives are common in the PC market. Hard

drives are usually built into the PC case and are usually very sensitive to shock and vibrations. They must be treated with care. If the disk and head come into contact, data can be lost due to a head crash.

Hardcopy

Creating a printout of the current contents of the screen by pressing the Shift Prt Sc keys. Following the printout, normal work can continue on the screen.

Hardware

Hardware consists of the computer itself and everything that pertains to it (processor, keyboard, monitor, disk drives, hard drive). The opposite of hardware is software.

Head crash

Damage of the hard drive and possible loss of data through the contact between the medium and the read/write head on the hard drive. This can be caused by dropping or moving your computer while the hard drive is operating. You should always use the SHIP or PARK command to place the read/write head in an area where a head crash cannot occur.

Hercules Graphics Card

Also known by its acronym HGC. It features a text mode of MDA and a graphics mode with a resolution of 720 x 348 one color (monochrome) pixels. Since 1982 the Hercules card (and compatibles) have been the most commonly used PC monitor adapter.

Hertz (Hz)

A unit of measure that's equal to a frequency of one cycle per second.

Hexadecimal

This is a numbering system that uses 16 digits, which includes the letters A through Z, as well as the numerals 0 through 9.

High-density

The storage capacity of a floppy disk or drive in which 15 or 18 sectors per track are recorded using MFM encoding.

High-level format

A DOS formatting operation to include important sections, such as the FAT, the boot record, free tracks, and others on the hard drive.

IBM compatible

Clones of the IBM PC/XT/AT computers, which follow the IBM "industry standard." If programs and hardware configurations follow the IBM standard, software can work with any computer. There are many IBM compatible computers that are more

efficient than the original IBM computer. However, this efficiency may mean that only 95% of the software written for IBM will work on an IBM compatible computer.

IDE
Acronym for Integrated Drive Electronics. This describes a hard drive with the disk controller circuitry integrated within it.

Impact printer
See *Dot matrix printer.*

Interface
Connection between a PC and the outside world. The PC and other devices can exchange data through this connection. Two types of interfaces are used: Parallel interfaces (see *Centronics*) and serial interfaces (see *RS-232 interface*).

Initialization
Another term for the process of formatting a diskette or hard drive so that it can be used.

Install
A process of attaching cards or other devices to the appropriate connectors or sockets.

Integrated circuit (IC)
A complex electronic circuit with multiple transistors and other electrical components on a single piece of material.

Interleave ratio
Also called interleave setting. This is the ratio between the physical sectors of a hard drive that are skipped for every sector used. For example, if the hard drive has an interleave ratio of 3:1, the disk writes to one sector, skips three sectors, writes to one sector, etc.

IRQ
Acronym for Interrupt ReQuest. This is a connection between external hardware devices and the interrupt controller.

ISDN
Acronym for Integrated Services Digital Network. An international telecommunications standard that enables a communications channel to carry digital data simultaneously with voice and video information.

Jumper
Electrical connectors that allow you to customize a circuit board. It's a small piece of rectangular plastic with up to three receptacles.

K
See *Kilobyte.*

Keyboard
The most widely used device for data input.

Kilobyte (K)
1,024 bytes and usually abbreviated simply as K, for example, 512K.

LABEL
The LABEL command permits the user to add an 11-character volume label name to the disk currently in the drive. Unlike filenames, volume names can include spaces. LABEL must be loaded from a DOS disk because it's a transient command.

Laser printer
Printer that creates characters on paper with a special printing process that uses an industrial laser. Laser printers are still expensive, however they're extremely quiet and have excellent print quality.

LCD
An acronym for Liquid Crystal Display. This display uses liquid crystal sealed between two pieces of polarized glass.

LED
An acronym for Light-Emitting Diode. This is a semi-conductor diode that emits light when a current is passed through it.

LIM/EMS Standard
A standard, introduced by Lotus, Intel, and Microsoft, that enables software to work with expanded memory above the normal 640K of RAM. Remember that software must be designed to run under the LIM/EMS standard in order to work with expanded memory.

Logical drive
A subdivision of a hard drive indicated by a specific letter. The first subdivision is usually designated as D because the primary partition is designated as C. Any other partitions can contain any number of logical drives designated by a different letter. Use the FDISK command to create partitions and logical drives. See also *Partition.*

Low-level format
Also called physical format. This is the physical pattern of tracks and sectors created on a disk during formatting.

Magneto-optical recording

An erasable optical disk recording technique that uses a laser beam to heat pits on the disk surface to the point at which a magnet can make flux changes.

Mathematical coprocessor

A microprocessor that increases the speed of the main processor by performing mathematical operations.

MCA

Acronym for Micro Channel Architecture. This includes a 16 or 32-bit bus width and multiple master control.

MCGA

Acronym for MultiColor Graphics Array. A type of video display circuit that supports text and graphics.

MDA

An acronym for Monochrome Display Adapter. A type of video display adapter that supports only text.

Meg

Abbreviation for megabyte (1,024K). Also sometimes abbreviated as Mb.

Megahertz (MHz)

A unit of measure that equals a frequency of 1 million cycles per second.

Microprocessor

Another word for chip. When used in computer science, the term chip usually refers to the main microprocessor of the computer, which controls the basic functions.

Modified Frequency Modulation Procedure (MFM)

A specific method of storing digital information onto a diskette one bit at a time. It's the least expensive but most inefficient method of storing information. See also *Run-length limited (RLL).*

Motherboard

Also called logic board. It's the large printed circuit board containing the CPU, support chips, RAM, and expansion slots.

Mouse

Controls the cursor. The mouse is a small box with two or three buttons on top and a ball poking out the bottom. When you move the mouse across a flat surface, the cursor moves in the same direction on the screen. The mouse is important for graphics programs and graphical user interfaces.

MS-DOS

The standard operating system that was developed by the Microsoft Corporation for IBM compatible PCs. Your PC is usable only after the MS-DOS operating system has been loaded. It consists of numerous resident and transient commands that can be accessed when needed.

Nanosecond

A unit of time equal to one billionth of a second. It's abbreviated as ns.

NLQ

Abbreviation for Near-Letter-Quality. Higher print quality offered by dot-matrix printers. The printer prints a line, then reprints the same line after slightly shifting the position of the printhead. NLQ mode reduces print speed considerably.

Operating system

The program that enables the computer to perform basic memory and disk management tasks. It permits the user to communicate with the computer through the keyboard. The operating system can be loaded from a disk (MS-DOS) or it can be stored permanently in the computer.

OS/2

An operating system developed by IBM and Microsoft Corporation. OS/2 is the successor to DOS and uses the Protected mode operation of the processor to expand memory and to support multitasking.

PAL

Acronym for Programmable Array Logic. A type of chip that has logic gates specified by a device programmer.

Parallel interface

Centronics interface, usually leading to a printer (see also *Centronics*). Parallel interfaces exchange data 8 bits at a time. LPT1: is the device designation for the first parallel interface. Additional parallel interfaces (if present) are accessed as LPT2: and LPT3:.

Parameter

Command elements of a DOS command separated from the command name by a space. The command COPY CON FILENAME uses the command name COPY and the two parameters CON and FILENAME.

Partition

See *Primary DOS partition* or *Extended DOS partition.*

PATH

The PATH command indicates the directory in which DOS should search for the resident DOS commands. Without such a path, the search is limited to the current directory. PATH without a parameter displays the path that has been set.

Pathname

Indicates the location of a file or a directory on a volume. It consists of the drive specifier and subdirectories separated by a backslash. For example, a valid pathname for a file named TEXT.TXT could be:

```
A:\text\private\Text.txt
```

PC

Abbreviation for Personal Computer, which was originally an IBM product introduced in 1981. Its name indicated that it was designed to be used by individuals. This was quite a change from the business systems of the time, which were large multiple user systems.

From this brand name came the generic description PC. It refers to all computers that are IBM compatible (able to use programs written for IBM computers). The introduction of the IBM PC/AT product line with an 80286 microprocessor was based on the concept of sharing system resources through a local area network (LAN). One AT would act as the "file server" for several PCs. The rapid drop in hardware prices and the failure of software producers to provide viable LANs makes these new and faster computers still a personal computer.

Port address

One of the system's addresses used by the computer to access devices, such as disk drives or printer ports.

POST

Acronym for Power-On Self-Test. It's a series of diagnostic tests automatically performed by the computer when you switch it on or restart it.

Power supply

An electrical component of the computer that prepares the electrical current for use by the circuitry of the computer. The size and quality of the power supply determines how many enhancements can be added to the computer, since most of them must be connected to the power supply. For example, a small capacity power supply may be able to handle only the computer and two disk drives, but not a hard drive.

Primary DOS partition

The main and bootable part of the hard drive. You must create the primary DOS partition for the hard drive.

Printer

Device that creates a hardcopy of computer data. Everything displayed on the screen is printed on paper. Printer types include: Daisywheel; dot-matrix, and laser. A printer can be addressed through either the serial or parallel interface of the computer. The parallel (Centronics) interface is designated by MS-DOS as LPT1: or PRN:. The serial (RS-232) interface is designated by MS-DOS as COM1:.

Processor

Abbreviation for microprocessor. Most references to a microprocessor in computing refer to the main microprocessor of the computer, (the central processing unit), which controls the computer's internal tasks (e.g., math, data movement).

Protected mode

Advanced feature of the 286 and 386 processors where memory is protected and allocated for specific programs and extended memory.

RAM

Abbreviation for Random Access Memory. This is memory in which data can be stored temporarily. Unlike ROM, RAM can be written to and read from. The contents of RAM disappear when the computer is switched off. See also *ROM*.

RAM disk

Pseudo disk drive created in the computer's RAM with the help of a program on the DOS disk. Because it is not a mechanical device, the RAM disk allows very fast file access, but loses all data when the computer is switched off. The RAM disk is extremely important to PC users that have only one disk drive. Anything can be kept in a RAM disk, if the files don't exceed the memory limits set for the RAM disk.

Read

The process of retrieving data, usually from a hard drive or floppy disk drive.

Real mode

An operating mode where specific memory locations are given to programs and peripherals.

Refresh

The process of repeating the storage of data to keep it from fading or becoming lost. DRAM must be constantly refreshed.

Removable storage systems

A secondary, usually high capacity, storage device. The diskette or tape is inside a cartridge or cassette that can be removed from the drive for safekeeping. Examples include Bernoulli boxes.

Resolution

A measurement expressed in horizontal and vertical dots for printers and pixels for monitors. The larger the resolution, the sharper and better the image.

RLL-procedure

See *Run-length limited procedure.*

ROM

Abbreviation for Read Only Memory. ROM consists of information permanently stored on a chip (see *Chip*), which remains intact after the computer is switched on. When the user switches on the computer, it reads the information from this ROM as needed. Unlike RAM, the user cannot write to ROM (hence the name).

ROM BIOS

The two ROM chips that contain BIOS code (Basic Input Output System) and system configuration information. See also *BIOS*.

Root directory

The main directory, located on either a floppy disk or a hard drive. It's the highest level directory. This root directory can be accessed by entering the drive letter, the colon, and a backslash.

RS-232 interface

Standard serial interface. With serial transfer, data is transferred one bit at a time.

Run-length limited procedure (RLL)

A specific method of storing digital information onto a diskette in a tight format. It stores almost twice as much data as the MFM procedure. Although more expensive, it's also a more efficient method of storing information compared to the MFM procedure. See also *Modified Frequency Modulation Procedure (MFM).*

SCSI

An acronym for Small Computer System Interface. Uses a 50-pin connector and allows multiple devices to be connected in daisy-chain fashion.

Sector

A small portion of the track on a disk. It's the area the computer uses to store data at specific locations on the disk for retrieval. Normal PC sectors contain 512K of usable area.

Seek time

The amount of time required for a disk drive to move the heads across one-third of the total number or cylinders. Seek time is a part of the average access time for a drive.

Serial interface
See *RS-232 interface.*

SIMM
Acronym for Single In-line Memory Module. These are memory modules plugged into the motherboard or memory expansion boards. They usually store data 9-bits wide and add 256K or 1 Meg of RAM.

Single density
A diskette type with a very limited amount of magnetic media. Most inexpensive diskettes are single density. Avoid using single density diskettes on your PC; use only double density diskettes.

Single sided
A diskette that is single sided can record on only the "top" side. Most inexpensive diskettes are single sided. Avoid using single sided diskettes on your PC; use double sided diskettes only.

SIP
Acronym for Single In-line Packages. A DIP-like package with only one row of leads.

Slot
Name for a connector inside the PC where additional circuit cards can be inserted to enhance the capabilities of the computer. Some PCs don't have these slots, so they cannot be enhanced easily.

Small Computer System Interface (SCSI)
An interface standard for hard drives and other peripherals.

Software
Computer programs, including the operating system and any drivers for peripheral devices.

Software Cache
See *Cache.*

Spreadsheet
Application program, often used for accounting, calculations, data tracking, business, and finance. As its name implies, a spreadsheet displays a set of cells into which numeric data and characters may be entered, similar to a printed accountant's spreadsheet.

Startup
See *Cold start* and *Warm start.*

Storage capacity
The quantity of data the computer can store and access internally. The PC generally has from about 256,000 up to 1,000,000 characters (256K to 1 Meg=1000 kilobytes) of memory capacity.

Storage media
The various devices used to store the contents of the PC's memory outside the computer. Generally these include disk drives, hard drives, and tape drives.

Subdirectory
Refers to a directory stored within another directory.

System prompt
Characters displayed on the screen, indicating that the computer is ready to receive input from the user.

Target disk
Also called the destination disk. It's the disk that will receive data during the backup procedure. When copying data from one disk to another, the disk being copied is the source disk and the disk receiving data is the target disk.

Track
One of several concentric rings encoded on a disk during the low-level format. The tracks allow the computer to store data at specific locations on the disk. See also *Sector*.

TSR
An acronym for Terminate-and-Stay-Resident. A program that remains in memory after being loaded.

TTL
An acronym for Transistor-to-Transistor Logic. TTL is a digital circuit in which the output is derived from two transistors.

User interface
The communication point between the user and the computer. In DOS, commands are entered through the keyboard. Other user interfaces allow communication with the computer through the use of other input devices, such as a mouse or joystick.

Utilities
Programs that either help the programmer program more efficiently, or act as tools for helping the user with disk and file management. For example, some utilities optimize the performance of a hard drive, while others help the user recover deleted or destroyed files.

VGA

Acronym for Video Graphics Adapter. It's a video display standard that offers a maximum of 256 colors simultaneously and provides better resolution than previous standards.

Virtual memory

This is a technique that simulates more memory than actually exists and allows the computer to run several programs simultaneously.

Warm start

The easiest way to return the PC to its original condition is to switch off the power (see *Cold start*). However, the warm start deletes the contents of memory and restarts the system without reloading the BIOS. This means that the computer doesn't count up its memory capacity, test peripherals, etc. Pressing Ctrl+Alt+Del warm starts the computer.

Whetstone

A benchmark program developed and designed to simulate arithmetic-intensive programs used in scientific computing. The speed at which a system performs floating-point operations often is measured in units of Whetstones.

Word processor

An application program for creating and editing text files. Most of today's word processors provide graphics and text formatting capabilities.

Write

The process of storing data, usually onto a hard drive or floppy disk drive.

Write protect

Protects disks from accidental formatting or file deletion. Disks can be write-protected by covering the square slot on the left side with a paper sticker (5.25-inch diskettes) or by moving the write protect slider (3.5-inch diskettes). Data can be read from this disk into the memory of the PC, but changes cannot be made on the disk. The disk and its data are protected.

XT

Designation of a PC with a hard drive or a PC capable of running a hard drive.

Y-connector

A Y-shaped splitter cable that divides a source input into two output signals.

APPENDIX

F Timeline

This appendix contains an overview of the important events in the history of the PC.

1971

The 4004 makes its debut as the first microprocessor. This 4-bit processor, developed by INTEL, contained over 2000 transistors. With a clock frequency of up to 1 MHz, it could perform 60,000 instructions per second.

1972

An 8-bit version, called the 8008, follows the 4004.

1974

The successor to previous microprocessors, called the 8080, is widely used.

1975

Digital Research introduces CP/M, an operating system developed for the 8080. Together with the 8080, this operating system will be the standard for 8-bit computers for many years.

1976

The improved 8085 makes its debut. At the same time, the Zilog company introduces the Z80, a processor based on the 8080 that's available at a much lower price.

1977

The Apple II and the Commodore PET lay the foundation for the development of the PC, or home computer. These two computers included the Zilog Z80 or the 6502 from MOS, which was also developed from the 8080.

1978

Intel introduces a 16-bit processor called the 8086 and a numeric processor called the 8087. The high cost of these two products, along with the high cost of 16-bit peripherals, discouraged potential buyers.

1979

Intel introduces the less expensive 8088, which has only an 8-bit data bus, but is compatible to the 8086 in every other respect. At the same time, in an attempt to establish 16-bit technology, Motorola introduces the 68000. Although this processor has a 32-bit register, it is a 16-bit processor in every other way. This processor and its successors were very important in computers manufactured by Apple, Atari and Next.

1981

The IBM PC is born. It's equipped with a 4.7 MHz 8088 processor and 64K RAM. The PC includes MS-DOS 1.0, which consists of three files and some utilities. The operating system must be loaded from a diskette, or it can be booted from ROM-BASIC. The PC has an excellent keyboard and a green monochrome screen that cannot display graphics.

1982

Intel completes development of the 80286. This 16-bit processor, which contains almost 150,000 transistors, can address 16 Meg of RAM with its 24-bit wide address bus. The 80286 is fully compatible to 8088s and has Protected mode, which makes hardware multitasking and even multi-user operation possible.

MS-DOS Version 1.1 now supports double-sided diskettes with a capacity of 360K. Errors in the Basic interpreter have been eliminated.

1983

IBM introduces the XT, which has a 10 Meg hard drive.

MS-DOS 2.0 appears at the same time, with hard drive support and a tree-like directory structure. Version 2.11 follows later in the year and is able to display national character sets.

1984

The IBM AT is the first computer to include an 80286 CPU. The AT is a 6 MHz computer with a 20 Meg hard drive and a high density drive with 1.2 Meg capacity.

MS-DOS 3.0, which was introduced at the same time, supports all of these new functions.

1985

MS-DOS Version 3.2 is network capable and now supports 720K 3.5-inch diskettes, even though IBM doesn't yet offer this kind of disk drive.

1986

The Intel 80386 is introduced. This new processor has a 32-bit address and data bus, expanded multitasking capacities, and Virtual Real mode, which makes simulation of several (virtual) XTs possible. In the same year, Compaq introduces the first computer with the new CPU, Deskpro 386. However, software products capable of utilizing the features of the 386 aren't available yet.

1987

MS-DOS 3.3 allows the operation of 1.44 Meg 3.5-inch disk drives. By creating an extended partition, you can also run hard drives that are larger than 32 Meg.

1988

IBM departs from the standard created by its own computers and introduces the PS/2 series. Because of the altered bus system, Microchannel, it's no longer possible to use cards for the ISA bus. However, IBM equipped the new computers with a 3.5-inch disk drive at 1.44 Meg capacity. It also set a new standard for graphics cards with the VGA adapter, which is capable of displaying 256 colors simultaneously. This

standard is still valid. The top model of the PS/2 series, Model 80, was the first IBM computer to use the 80386 processor.

A new operating system, developed by Microsoft, appears at the same time as the PS/2 series. This operating system is called OS/2, which stands for Operating System 2. It utilizes the capacities of the 286 in Protected mode, enabling genuine multitasking for the first time with full MS-DOS compatibility.

Microsoft introduces MS-DOS Version 4.0, a graphical user interface. MS-DOS 4.0 also supports the creation of DOS partitions larger than 32 Meg, as well as linking expanded memory to 386 systems.

In response to Microchannel, the leading computer manufacturers of the world came out with the EISA bus, a 32-bit slot system compatible to the ISA bus. This system makes it possible to continue using all the old cards.

1989

The Intel 80486 is introduced. This highly integrated processor contains a 386, a 387, and an internal cache controller with 2x4K cache memory. As a result of a fundamental revision of the internal communication structure, the 486 has about 2.5 times the performance of a 386 with a coprocessor.

MS-DOS Version 4.01 has fewer defects than previous versions, but still uses a tremendous amount of memory.

1991

After large-scale testing, MS-DOS 5.0 is introduced. This new version allows swapping of operating system parts and device drivers to extended memory, which frees up as much as 630K of main memory for DOS applications. The significantly improved DOS Shell allows limited multitasking or task switching. The operating system supports 2.88 Meg 3.5-inch disk drives as well as a wide variety of accessory programs, such as a program for recovering accidentally deleted files.

1992

Currently Intel is developing the i586 processor. The new processor is supposed to have genuine RISC architecture and about 2.5 times the performance of the 486. Marketers are trying to make the 486 the standard.

IBM is trying to go its own way on the operating system sector with Version 2.0 of OS/2. This operating system has all the advantages of a real 32 bit operating system

for an extremely low price. It also contains a complete DOS and a complete Windows.

1993

Microsoft releases a new Version 6 of DOS. MS-DOS 6 has a powerful help system, offers improved data security, with programs for virus detection, backups and recovery of deleted files, automatic data compression, a defrag to reorganize your hard drive and a memory optimizer. A new hard drive cache (SMARTDRV.EXE) offers improved performance with Windows and compressed hard drives.

IBM releases OS/2 2.1, a multitasking/multithreading operating system so several programs can be executed simultaneously (multitasking).

Intel introduces the next generation Pentium. The Pentium processor. The 486 chip contains the equivalent of 1.2 million transistors. A Pentium has more than 3 million transistors on board.

Today, everybody's talking about multimedia. After a slow start, PCs (both DOS and Windows) are now "multimedia capable." Previously, only a few complex applications were multimedia capable.

Microsoft releases a new version of Windows called Windows NT (New Technology) in the summer of 1993. Unlike its predecessors, it's actually a full-fledged operating system that will not only fully use the 32-bit mode of 386 and 486 processors, but will also be able to exchange programs with other computer systems, such as Apple or NeXt systems.

1994

Intel ships two new 100 MHz processors: the Pentium and 486DX4-100.

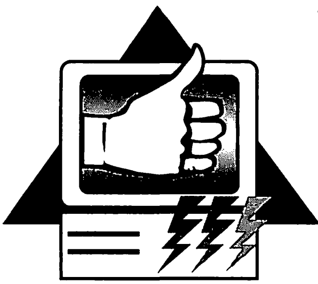
COMPAQ Computer Corporation becomes largest producer of PC computers.

IBM and Eastman Kodak announce agreement to include Kodak Photo CD imaging technology in IBM's new 'personal' OS/2 operating system.

Wordperfect Corporation is purchased by Novell Corporation.

Microsoft settles 3 year old FCC investigation into unfair trade practices.

Microsoft announces the 1994 debut of Windows 4, code-named Chicago, will ship early 1995.



APPENDIX G Companion Diskette

The companion diskette contains several practical utilities for PC testing and maintenance.

Installation

Insert the companion diskette in a disk drive. Log to that drive, and type the following:

```
INSTALL
```

and press Enter.

The INSTALL program will ask you for a source drive and a destination drive. Follow the instructions on the screen. The INSTALL program creates an ABACUS\UPGRADE directory, then creates subdirectories, into which the programs are inserted.

The companion diskette provides you with the following shareware and public domain utilities. Please remember to support the shareware authors by registering these products with them.

Each description below states the directory and program filename, as well as a brief description of the program and author credit.

CMOS\CMOS.EXE

This shareware program by Vertical Solutions lets you save and load CMOS data to and from diskette. This is handy if your battery backup dies. CMOS is an acronym for Complementary Metal-Oxide Semiconductor. This chip duplicates the functions of other chips, and is used in battery backed up data storage (e.g., clock time and video setup). See Chapter 8 (CMOS SETUP with AMI-BIOS) for more details on how one form of CMOS works.

SYSCACHE\CT

CACHE TEST Version 4.2 by George Spafford. This program tests out disk cache efficiency, and how it affects drive performance. You would actually run CT twice—once without your disk cache program running, and once with your disk cache program running. Just log to this directory, type:

```
CT
```

and press Enter.

EHD\EHD.BAT

This batch file set, written by the authors, lets you create a deluxe FAILSAFE diskette based on your DOS implementation. We discussed creating a FAILSAFE diskette in Chapter 7 of this book, using basic methods, but this set of batch files creates a bootable diskette, writing to it the files you'll need for booting and essential DOS survival, based on the version of MS-DOS running on your system.

Boot from your hard drive. Copy the contents of the EHD directory to your operating system directory (e.g., DOS). From that operating system directory, type:

```
EHD
```

and press Enter.

EHD instructs you to insert a diskette for formatting in drive A:. It will then generate a bootable diskette and copy the necessary files to this diskette. Run this utility before you make any changes to your hard drive's CONFIG.SYS or AUTOEXEC.BAT files. Then if you've made an error, you can always reboot using this diskette, and copy your old AUTOEXEC.BAT and CONFIG.SYS files to the hard drive.

FIXDSK\FIXDSK.COM

An especially useful utility for older 286 and 386 machines, by Michael J. Markowitz. Somewhere in the ROM BIOS, a disk bug exists, causing read and other errors. FIXDSK alleviates those errors.

PCINFO\PCINFO.EXE

The PCINFO program was documented earlier in this book (see Chapter 12). You'll find it in executable form, and as Pascal and assembly language source code, on this companion diskette.

RDMYDISK\RMD!.EXE

Written by R. Harriman of Dairysoft Custom Software, Maine. Lets you recover ASCII data from a damaged floppy diskette or hard drive caused by physical damage such as being folded in half and stuffed into the mailbox or scratches.

SLEUTH\SLEUTH.EXE

System Sleuth Analyzer on the companion diskette by Dariana, Inc., is a powerful information gathering program for PC, viewing PC configuration, drives, display, and even hardware interrupt assignments.

System Sleuth Analyzer requires an IBM PC, PC/XT, PC/AT, or 100% compatible computer; 256K RAM installed and 192K of memory; monochrome, Hercules, CGA, EGA or VGA display adapter and monitor; and MS or PC DOS V 2.1 or higher.

To run System Sleuth Analyzer from the drive and directory containing the program type:

```
SLEUTH
```

and press [Enter].

Activate System Sleuth Analyzer menu system at any time by pressing [Alt]. Most menu items have context sensitive help (press [F1] for context sensitive help).

SYSCACHE\SYSCHK.EXE

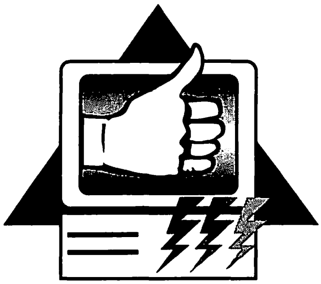
Another system information program, written by Advanced Personal Systems of Milpitas CA.

SYSINFO\SYSINFO.COM

Gary Moore's system information program gives you a "quick glance" at the system's capabilities.

CYRXTEST.BAT

This utility tells you which of Cyrix Upgrade Microprocessors can boost your 386 computer system to 486 class performance. Provided by Cyrix of Richardson, Texas, it is compatible with IBM and Compaq hardware and software standards. Upgrades are available for many 386SX and 386DX personal computers.



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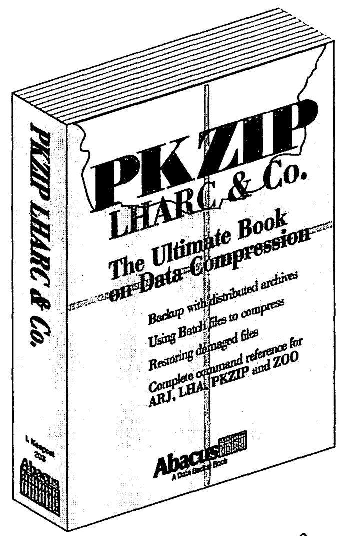
Productivity Series books are for users who want to become more productive with their PC.

PKZIP, LHARC & Co.



Did you ever notice that you always seem to run out of space on your hard drive at the least opportune time? Luckily, there are ways to increase a computer's storage capacity with data compression. Several FREE and LOW-COST shareware utilities like PXZIP, LHARC, and ZOO are available for the asking.

PKZIP, LHARC & Co. shows you how to take advantage of the space-saving features that each utility offers. Not only will you learn how data compression works, but you'll find out how to take advantage of the hidden features of these valuable utilities: sharing files; automatically running compressed programs; protecting files with passwords; adding comments and notes to compressed files and much more.

You'll also learn about:

- Backing up and sharing compressed files
- Simplifying the job with batch files
- Restoring damaged archives
- Adding comments to your files
- Executable compression programs: LZEXE, PKLite and Diet
- File Compression programs: PKZIP, LHA, ARJ and ZOO

The companion disk includes data compression programs discussed in the book.

Author: Irene Kespret
Order Item: #B203
ISBN: 1-55755-203-7
Suggested retail price: $19.95 US/ $25.95 CAN with companion diskette

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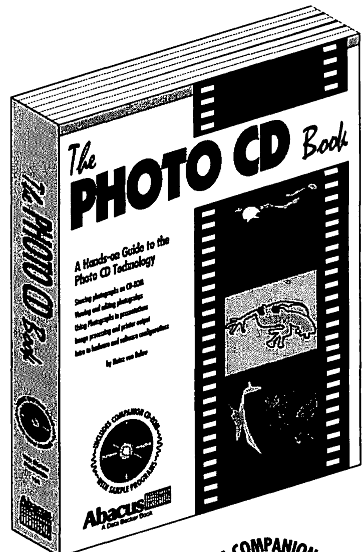
In US and Canada add $5.00 shipping and handling. Foreign orders add $13.00 per item.
Michigan residents add 4% sales tax.

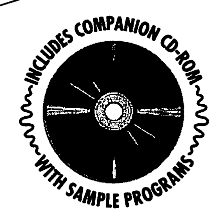
Multimedia Presentation

The Photo CD Book



The Photo CD Book is for all CD-ROM owners, multimedia enthusiasts, graphic artists, desktop publishers and users wanting to grasp the movement to Photo CDs and this exciting new digital image technology.

This book is your first source for learning and understanding the digital technology invented by Eastman Kodak to "replace" conventional photography. It's a "hands-on" way to learn and use the technology where you'll see how to turn your personal computer into a digital photo studio, darkroom lab and art gallery. From the basics of image processing and the tricks of photo retouching and enhancement, to the radical special effects of morphing and then finally to the on-screen exhibition halls for visual presentations, you'll get a complete coverage of where this technology is taking us.



Learn how the different hardware is used to record, manipulate and output Photo CD images. You'll also see how the various software packages can transform ordinary into sensational images. One section describes how to use Photo CD images with Micrografx PhotoMagic, Microsoft Publisher, CorelDraw, Aldus FreeHand and Photostyler, Adobe PhotoShop, and other popular software.

The companion CD-ROM has dozens of samplers including Toshiba's Photo/Graphic Viewer; MicroTek's Photo Star graphic utility; real PCD photo examples used in the book; a collection of the most popular shareware graphics utilities including PaintShop Pro and Graphics WorkShop; several industry standard Phillips CD-I software drivers.

Author: Heinz von Buelow and Dirk Paulissen
Order Item: #B195
ISBN: 1-55755-195-2
Suggested retail price: $29.95 US / $39.95 CAN includes CD-ROM

To order direct call Toll Free 1-800-451-4319

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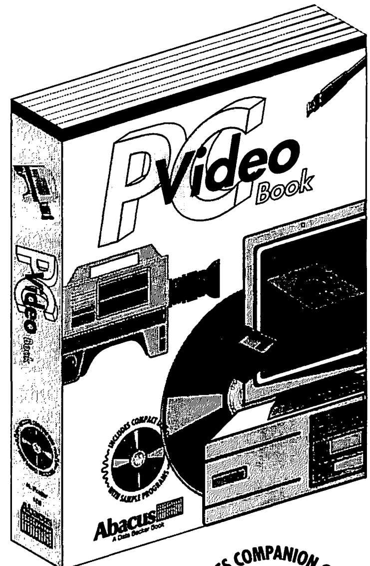
Multimedia Presentation

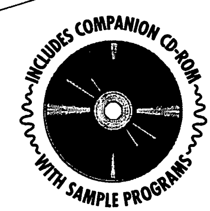
The PC Video Book

The PC Video Book teaches you the fundamentals of video technology and the hardware for creating your own videos on the PC. Quickly learn how to put credits in videos, how to adjust video color and write it back to the tape, and much more. It's the complete guide to video production including- video planning, digitizing, editing, changing color, adding effects, titles, and credits, etc. From the fundamentals of video technology to creating your own video productions- this book offers valuable tips, concrete shopping suggestions, and helpful explanations.



The book includes:

- Video production step-by-step
- Frame grabbing for desktop video
- Using Video for Windows
- File formats: AVI, FLC, FLI, DIB, WAV, PCM
- Creating and recording animations
- Capturing video and sound
- Choosing and connecting VCRs, camcorders and other hardware
- Editing video and sound clips



On the CD-ROM are hundreds of megabytes of digitized material (videos, images, sounds), which can be tried out and used in multimedia applications.

Authors: Kerstin Eisenkolb & Helge Weickardt
Order Item: #B265
ISBN: 1-55755-265-7
Suggested retail price: $34.95 US / $44.95 CAN includes CD-ROM

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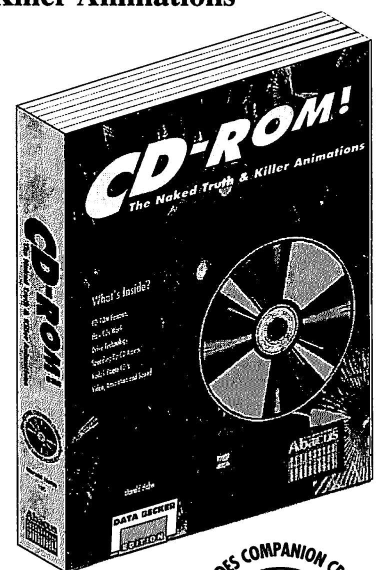
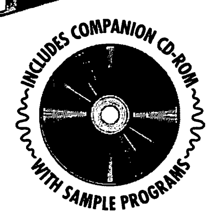
Multimedia Presentation

CD-ROM! The Naked Truth & Killer Animations



The multimedia explosion has been fueled by the drastic price reduction of CD-ROM drives. For the US, analysts predict that almost 15 million new CD-ROM drives will be sold this year! This book guides today's you through a better understanding of your CD-ROM drive and then lets you explore over 500 meg of programs and animations. CD-ROM The Naked Truth and Killer Animations is a valuable, "all-in-one" product for the CD-ROM, multimedia enthusiast. It's a book about CD-ROM technology with a ton of multimedia software to titillate your imagination.



CD-ROM! The Naked Truth and Killer Animations walks you through the nitty gritty and into the wild side of multimedia. The newcomer will learn all about installation, hardware configuration, and how he can optimize, configure and tune his computer system for the best performance. Complete with software utilities, you'll be able to check and test the performance of the CD-ROM drive. Not only that, there's a special "caching" program, HyperDisk, that helps you juice the speed of your drive with read-forward technology.

The book also includes:

* CD-ROM Formats
* How CDs Work
* Drive Technology
* Speeding Up CD Access
* Kodak Photo CD's
* Video, Animation and Sound
* Producing Customized CDs
* CD-ROM Programming
* Using CD-ROMs on Netware, and OS/2

Author: Harald Hahn
Order Item: #B266
ISBN: 1-55755-266-5
Suggested retail price: $39.95 US / $49.95 CAN includes CD-ROM

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The Companion Diskette

This book is a complete and practical guide to upgrading and maintaining your PC. This companion diskette features executable programs for storing CMOS information, creating bootable diskettes for emergency use, checking system and cache parameters, and even reading trashed diskettes.

Installation

Insert the companion diskette in a disk drive. Log to that drive, and type the following and press Enter:

```
INSTALL
```

The INSTALL program will ask you for a source drive and a destination drive. Follow the instructions on the screen. The INSTALL program creates an ABACUS\UPGRADE directory, then creates subdirectories, into which the programs are inserted.

ABACUS\UPGRADE directory
Contains all the program subdirectories and last-minute information as needed.

CMOS directory
Contains the CMOS program for saving and loading CMOS information.

SYSCACHE directory
Contains programs for testing disk caches and system parameters.

EHD directory
Contains a set of batch files for creating bootable diskettes (for emergency use).

FIXDISK directory
This directory contains a program for fixing a ROM BIOS disk bug that appeared in older 286 and 386 systems.

PCINFO directory
PCINFO contains the PCINFO.EXE program, which provides you with a detailed description of system capabilities. You'll also find Pascal and assembly language source code in this directory, so you can modify PCINFO to your own needs.

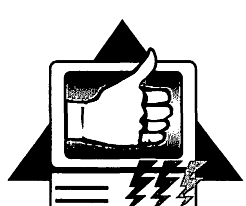
RDMYDISK directory
Contains the RMD!.EXE (READ MY DISK!) program for reading data from trashed diskettes.

HDTEST
Tests hard drives by using the HDTEST program.

SYSINFO directory
Contains the SYSINFO.EXE program for getting a quick overview of system capabilities.

SLUETH \ SLUETH.EXE
Is a powerful information gathering program for PC, viewing PC configuration, drives, display, and even hardware interrupt assignments.

CYRXTEST.BAT
This utility tells you which of Cyrix Upgrade Microprocessors can boost your 386 computer system to 486 class performance. Provided by Cyrix of Richardson, Texas, it is compatible with IBM and Compaq hardware and software standards. Upgrades are available for many 386SX and 386DX personal computers.



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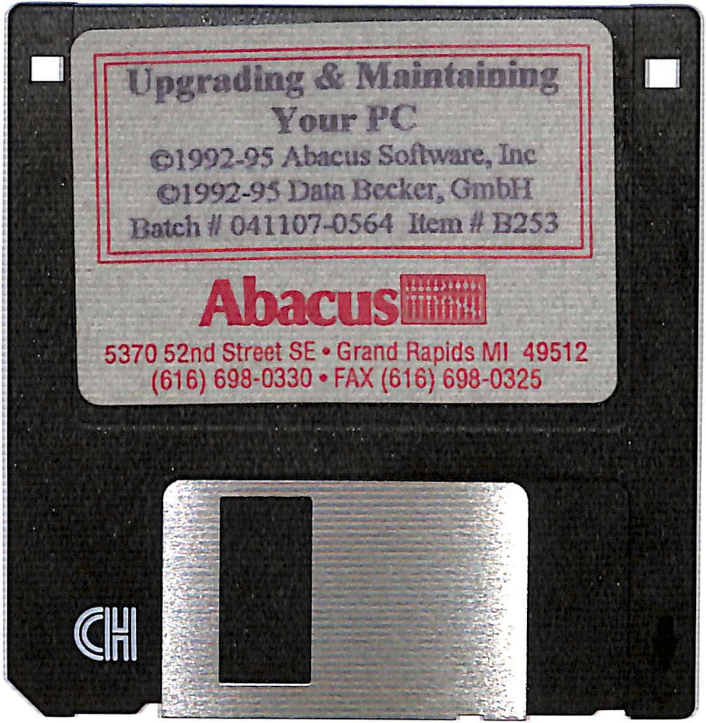
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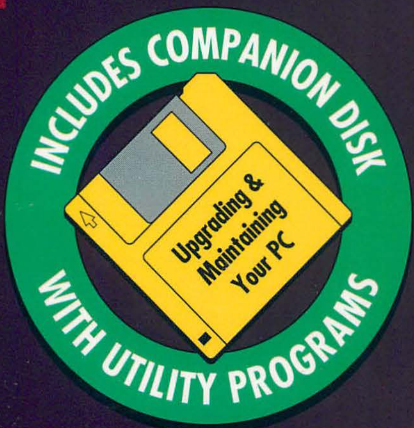
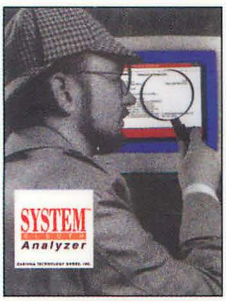


System Sleuth Analyzer from Dariana Technology Group, Inc. is on the companion diskette along with other useful utilities.

System Sleuth Analyzer is a $99.95 toolbox of valuable PC diagnostic aids rolled into a single, easy to use software utility. *System Sleuth* lets the user explore exacting details of your PC without the fear of accidental, unrecoverable modifications to a particular subsystem. The menu-driven interface displays all aspects of machine information for easy recognition. *System Sleuth Analyzer* displays and generates printouts of these areas:

System Overview
Input/Output Mapping
Memory Information
Hardware Interrupts
TSR Mapping
Hard Disk Drives
Video Analyzer



Companion diskette Includes:

- **CMOS Directory**
  This directory contains the CMOS.EXE program for saving and recalling the contents of your PC's CMOS (that area containing clock, disk and other configuration data).
- **EHD Directory**
  Uses a set batch files to create a bootable DOS diskette from your hard drive data. This diskette is useful if your hard drive dies, or if you mis-edit CONFIG.SYS or AUTOEXEC.BAT.
- **FIXDSK Directory**
  Contains the FIXDSK program, which repairs a BIOS bug, in older operating systems, that generated read and other errors.
- **HDTEST Directory**
  For testing hard drives with the HDTEST program.
- **PCINFO Directory**
  This directory includes the PCINFO program documented in Chapter 12.
- **RDMYDISK Directory**
  For recovering ASCII data from trashed diskettes using the READ MY DISK! program.
- **SLEUTH Directory**
  This directory contains the *System Sleuth Analyzer* by Dariana Technology Group.
- **SYSCACHE Directory**
  Includes the SYSCHK program for viewing PC capabilities in detail, and the CACHE TEST program for testing disk cache efficiency.
- **SYSINFO Directory**
  For getting a "quick look" at a PC's hardware with the SYSINFO program.

Upgrading & Maintaining Your PC

Buying a personal computer is a major investment. With **Upgrading & Maintaining Your PC**, you can learn time- and money-saving skills, tips and tricks for making the most of your investment. **Upgrading & Maintaining Your PC** will show you how to turn your ordinary PC into a high performance computing machine.

With up-to-the minute information on the hottest technology on the market today, **Upgrading & Maintaining Your PC** will give you the know-how to make the best purchasing decisions for upgrading and repairing your own personal computing system. Not only that, but it's in-depth enough that you can decide when a job is something you can handle doing yourself, or when it's complex enough that you would rather have an "expert" handle the job for you.

If your computer runs, but you're not satisfied with its performance...
If you would like to build your own PC...
If you're curious about what's "under the hood" and how it works...
If you would like to save time and money...
If you'd like to add a hard drive to your system...
If you want to know how to upgrade to get the best system possible from your existing PC...

...then **Upgrading & Maintaining Your PC** is for you!

In addition, a program on the companion diskette furnishes you with thorough, detailed information about the components of your computer.
See inside flap for more information.

This 3rd Edition of **Upgrading & Maintaining Your PC** covers these topics and more:

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- Replacing the CPU and defective components
- Optimizing the hard drive
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